

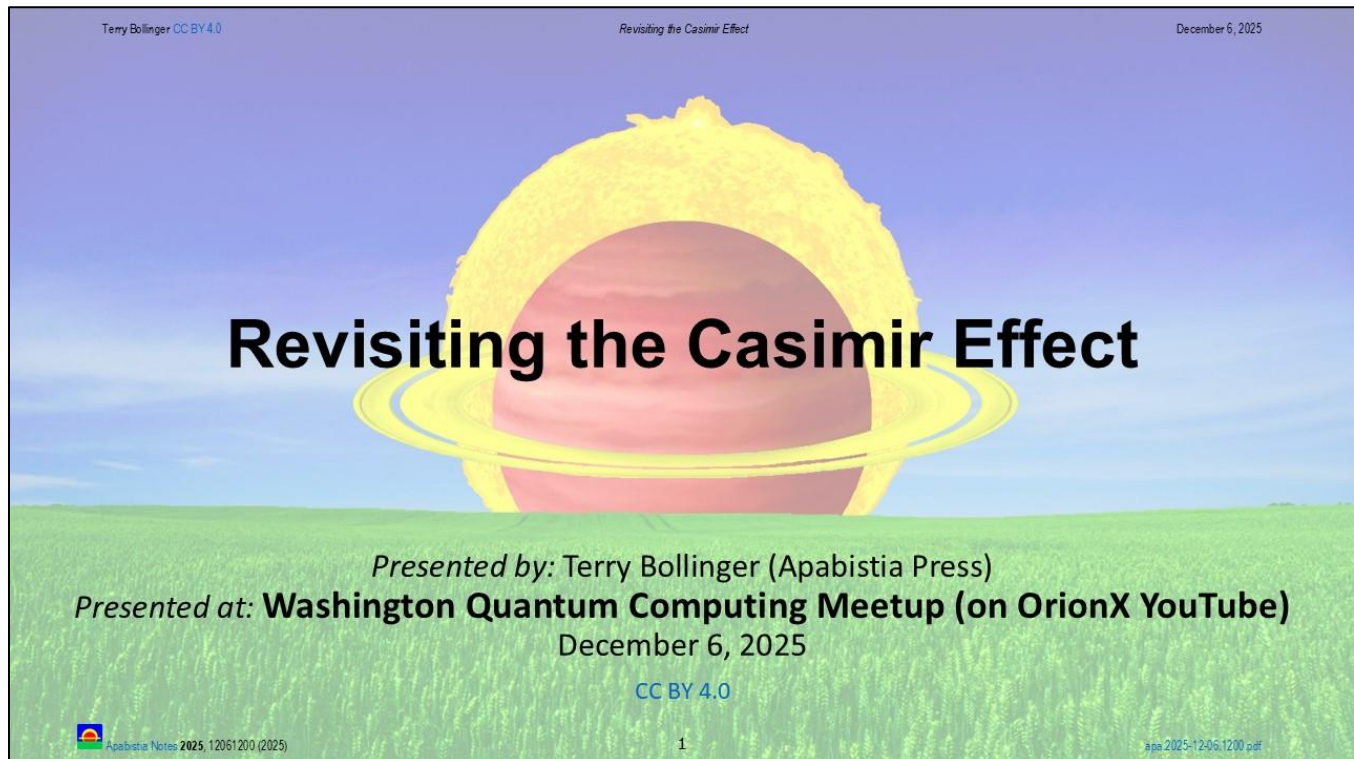
Revisiting the Casimir Effect

(Transcript with figures)

Terry Bollinger

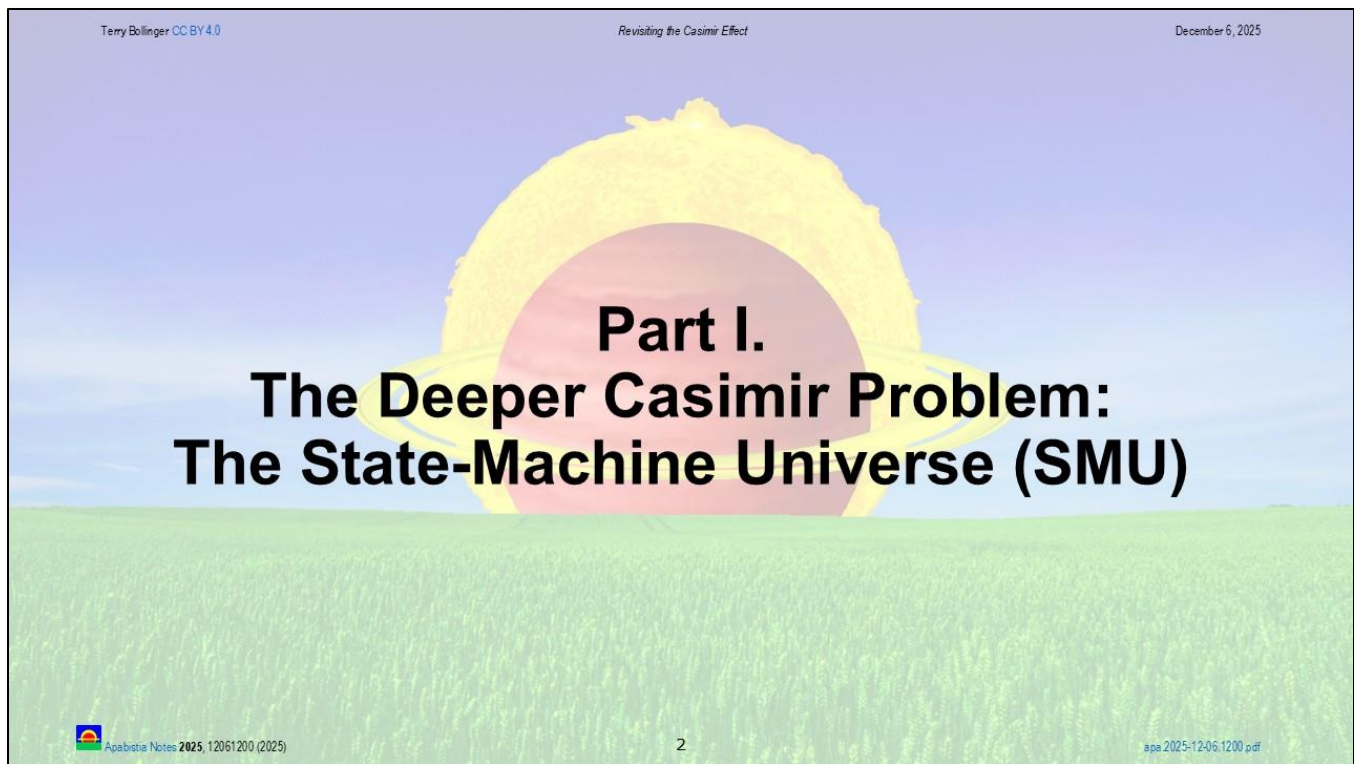
Presented at: Washington Quantum Computing Meetup (on OrionX YouTube)
2025-12-06.12:00 EST Sat

This is the edited YouTube transcript. You can view the full video at <https://youtu.be/eVEIdSF6QIY>



[0:0] TB: Good afternoon, good evening, good morning (depending on what time zone you're in).

The topic of the talk today is revisiting the Casimir effect, which is something I've addressed at least twice in some detail, and precisely for that reason I'm hitting a little bit more on some of my more recent work on special relativity, which is directly relevant to the Casimir effect, but also gives a different spin on that. So, if you're looking for a somewhat different perspective on some issues about special relativity, you've come to the right place, because there are some interesting differences here.



[\[0:40\]](#) The deeper problem with the Casimir effect...

The Casimir effect (just as a very brief introduction) is the idea that if you put two metal plates together there's a pressure that pushes them closer and closer together, and in doing so it... This force is supposed to show the almost infinite energy that resides inside of quantum uncertainty. So, it's a famous effect and was supported actually strongly by Bohr, although Casimir is the one who did the experiments, and it has had quite an impact on physics over the years. So, taking a different look at how space-time is structured becomes very relevant for how this Casimir problem... how the Casimir effect works out. So, this is the first dive. It's to go into something called the State-Machine Universe (SMU).

Beneath Space and Time Lies A State Machine

- All *testable* definitions of space and time require **matter and energy**
- All *testable* definitions of space and time require an **energy history**
- Result: Inertial frame spacetime definitions become **local only**
- Question: **If spacetime maths are *not* universal, what maths are?**
- Answer: **State machines**
 - Every inertial frame instance becomes a **subset state machine**
 - Space and time become **behavior patterns** encoded onto those subsets
- The universe remains **large-scale deterministic**. However, ...
- All concepts of “space” and “time” as **entities (fabrics) disappear**



[1:49] The premise is quite straightforward: that underneath space and time, rather than having a space-time fabric that simply resides there and exists (a very pre-existent kind of concept of that) there's another way of interpreting the universe that in many ways is actually closer to everyday perceptions. We talk about physics as the rules by which matter behaves and energy behaves and even making that statement is actually a statement very similar to what in computer science is called a state machine. That is you have a certain condition, you have a certain situation, you have a certain status, you do an operation on it, you apply an operator, and that transforms that matter into a new state, into a new version of the system.

So, this is actually a quite intuitive concept. It's not a concept that's difficult to understand even if you're not from a computer science background. It is the fundamental concept behind computer science. Every computer is a state machine. It has a memory. You have operators that you apply to that memory and they change the state of that machine and then you continue in a sequence to get the overall results that you want from this.

In physics however there's a tendency to have models that go beyond the simple statement of transitions under the rules of physics. You have definitions of matter and energy that extend for all of eternity in some cases. You have the idea of what's called a block universe in which everything is predetermined, preset, and many physicists have a lot of discussion about how now even exists, how the concept of what we're doing right now exists. Experimentally, that doesn't happen. Experimentally, you know that you're watching this right now, you know that certain things are happening. From your perspective you have a very definite idea of what is right now. You make a strong distinction between past and future.

So, a state machine in... as I say in some ways going back to a more intuitive concept of how physics operates... but the particular version of... In this particular version of it, the state machines, every inertial frame, rather than being a separate concept of space and time, something that extends to an indefinite length, it becomes a subset of how the state machine works. When you do this it has a curious effect of making the concepts of space and time into behavior patterns. You don't have this idea of a fully extending future, a fully extending past. You only have this idea that if you have certain sets of operators that work in a certain way you wind up getting a behavior that we then *interpret* as time. So this is a very *immediate* and very kind of a *pattern* type of interpretation of how you do that.



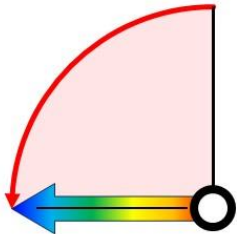
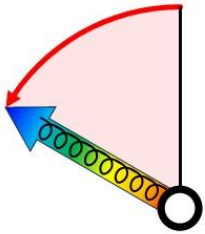
At the large scale, a state machine model still gives you the kind of large-scale only (not quantum), but it gives you the same kind of deterministic behavior that you expect. So this is not *incompatible* with the idea that you have a well-defined future for things like orbits, that you have certain patterns that can be predicted over very long lengths of time. However, it *does* change the way that you interpret how that happens. Instead of saying that that long-term pattern already exists, you're instead saying that you have operators that will persistently behave in a fashion that allows that future to be predicted.

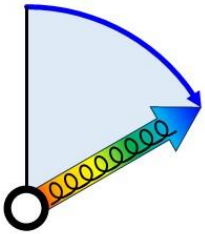
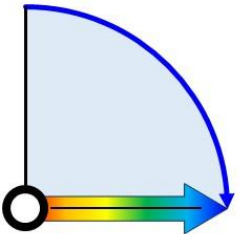
When you go this way, this idea... and I think most of us have this. We have this idea that (we're kind of trained into it informally)... it's that space and time (space-time together) is a fabric, is an actual substance, and not accidentally Einstein *very* much pursued this approach in his later years. In his early years he did not, but in his later years he took space-time not just as an *idea*, but as an actual fabric from which everything was composed and that remains a very common approach in doing these.

In terms of *experimental* that's a different issue, because experimentally you must have actual material objects before you can measure things like space and time... [{delay of several seconds due to technical problems}] and I'm *trying*... There it goes. For some reason, I could not get my button to go down.

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Dynamics: 1 DAU (Distance-Activity Unit) per Cycle

ALL NEGATIVE DISTANCE
MIXED
ALL ACTIVITY (ALL TIME)
MIXED
ALL POSITIVE DISTANCE

- One DAU per cycle **transforms its attached matter unit** to a new state
 - Vertical DAU = 100% Activity transformation (passage of time)
 - Horizontal DAU = 100% Distance transformation (relocation in space)
- Matter units are vastly multiscale, from particles to cosmic "walls"
- "Speed" movie analogy: **Activity = loops**, **Distance = straight driving**
 - Motion **cannot stop**, so the only options are loops (time) or travel (distance)

 Apabistia Notes 2025, 12061200 (2025)
4
apa.2025-12-06.1200.pdf

[6:28] Okay, so I'm saying that [in] a space-time interpretation you can take the *entire universe*, take each piece of it as an existing state of the universe and then that you have some kind of operators that you apply to that to go to the next version (the next iteration of the universe). Now, the unit that turns out to be extremely useful for doing this is what I call a distance activity unit. This is an invariant arrow that essentially is *attached* to every unit of matter that you might want to define.

The unit of matter can be pretty much any scale. You can have something that can be as small as a particle, it can be as large as a galaxy, and you can have a *scale* in which the time involved, which is the main metric that you use to define the length of this. The time metric could be an extremely small unit of time, a very large unit of time. It could be a million years, a million light years.

You can have, also very small nanosecond particle type things. The scale itself doesn't really matter. The idea is that if you *have* a unit of matter that can be *defined* as a well instantiated unit, something that persists... So you have an object. This is very much the object idea. A star is an object. A block of matter that is moving through space is an object.

Anything that has that kind of unity where you can define it so that it goes through a period of time has this ability to have a transformation that can go in a number of different directions in the future, and the directions are the angle of this arrow, so that you *move* the angle... If you're in one place, you go strictly into a pattern that we'd interpret as time, whereas if you go in another direction you can go (ideally, you can't... it takes infinite energy to do this) in a completely straight line, which is the same thing as traveling at the speed of light.

Now, notice there's no light cone in this. This is just talking about the transformations that you're doing to the *state* of that unit of matter. That's a different thing from saying the actual... You're not trying to track the light cone aspect of this, but rather the transformations that you're applying. A *useful* analogy in this, interestingly enough, is this idea... and I can't help but reference the movie *Speed* [(1994)], because it just gives a delightfully appropriate example: You've got somebody stuck in a bus. The bus cannot slow down. It always has to go somewhere. So in some parts of the movie, they're just looping around and going in a circle. Then in other parts, they have to go in a straight line, but there's always this constant speed that is trying to drive this bus.

Well, it turns out the relationship between space and time (between time and space, between time and distance) works very much like that. You have an unavoidable activity, which is the looping part. That's where you can actually do something, where you can change state locally, where you can turn the dial of a clock, where you can watch something and observe it. There's always a cyclic aspect to any kind of time measurement, which we see very literally on time dials, but on the other hand you can take that same motion and extend it out *all* the way to the right, transform that into a distance, and that's where you go at the speed of light and time comes to a complete stop, because you've used up all of your internal velocity, not for the activity part (the coiling part, the looping part) but you've converted it entirely into distance.

Now, what's interesting about this structure, about using these ideas of DAU [(Distance-Activity Units)] units...

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Adouane-Bollinger Diagonal (ABD) Spacetime

ALL NEGATIVE DISTANCE
MIXED
ALL ACTIVITY (ALL TIME)
MIXED
ALL POSITIVE DISTANCE

➤ An impressive simplification by the [EttanEhsan YouTube](#) channel:

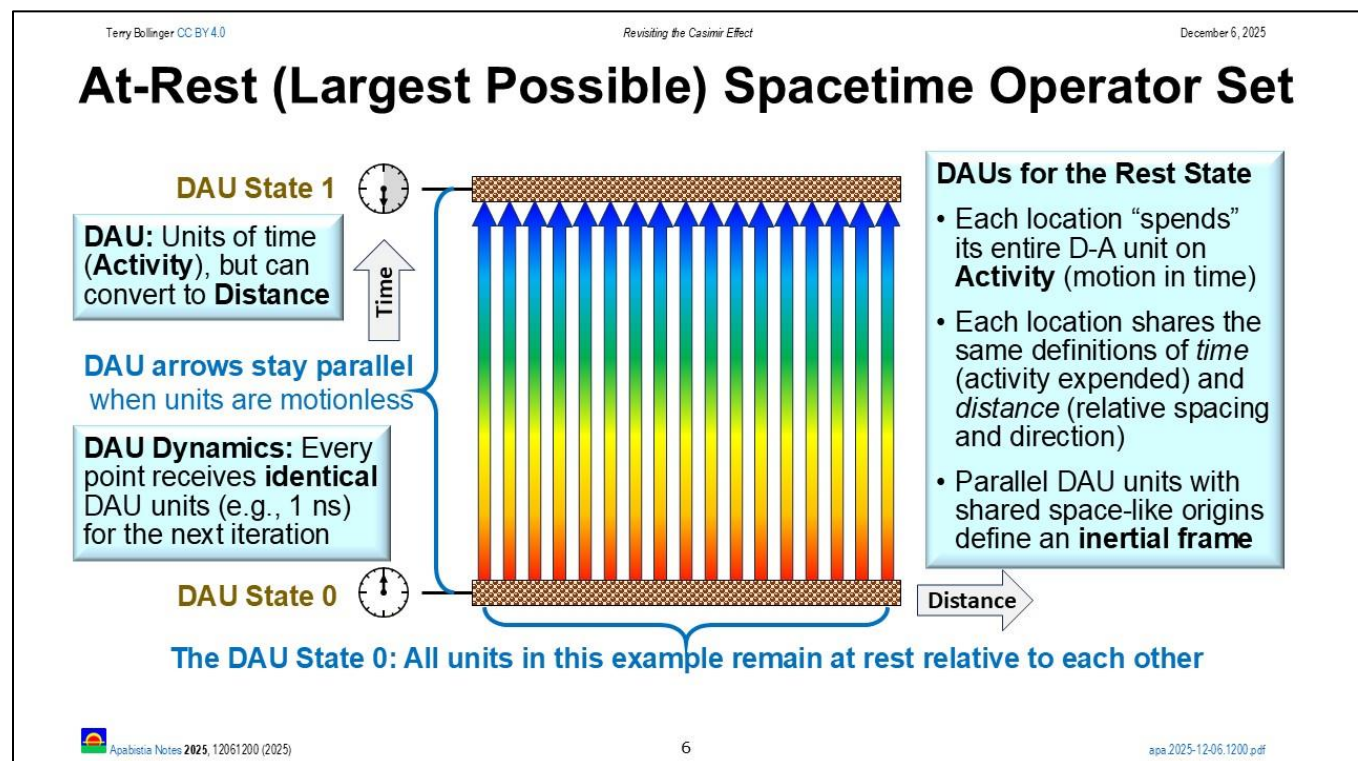
- Every choice of a DAU unit angle (θ in the figures) forms a box
- The DAU unit stays the same length and forms the diagonal of the box
- The box fully defines the *interchangeability of space and time*
- Its **height** defines the **time elapsed** for that unit during this cycle (cosine θ)
- Its **width** defines the **space traveled** during this cycle (sine θ)

Apabistia Notes 2025, 12061200 (2025)
5
apa.2025-12-06.1200.pdf

[10:09] ... is that it immediately gives you the results of special relativity that are often done in a much more complicated fashion. You have an angle and the angle tells you how much you've tilted the operator (the next iteration of the state machine for that object). You can have it go straight up, in which case, it's pure time. You have the fastest clock of anybody around you. The clock just keeps on going in a circle, but you can also stretch it out to different angles and go to the right or go to the left, you have a choice on that, and by the way notice the theta $[(\theta)]$ convention. I put a plus sign there because I am using the reverse. These are the clockwise plus angle, which is a little different from some of the other representations. So just in case you want to get picky about that notice that it is a plus in the right-hand direction.

So you go all the way over to the right and the state change that you would induce on that object is purely one of translation (of moving to a different point in space). If you're familiar with the concept of an interval in spatial relativity, an object that moves at the speed of light is said to be in some sense *simultaneous* or in the *same location*. Now the interesting thing is, we know that's not really true because if something's moving at speed of light, yeah, the time stops, but it also changes the distance.

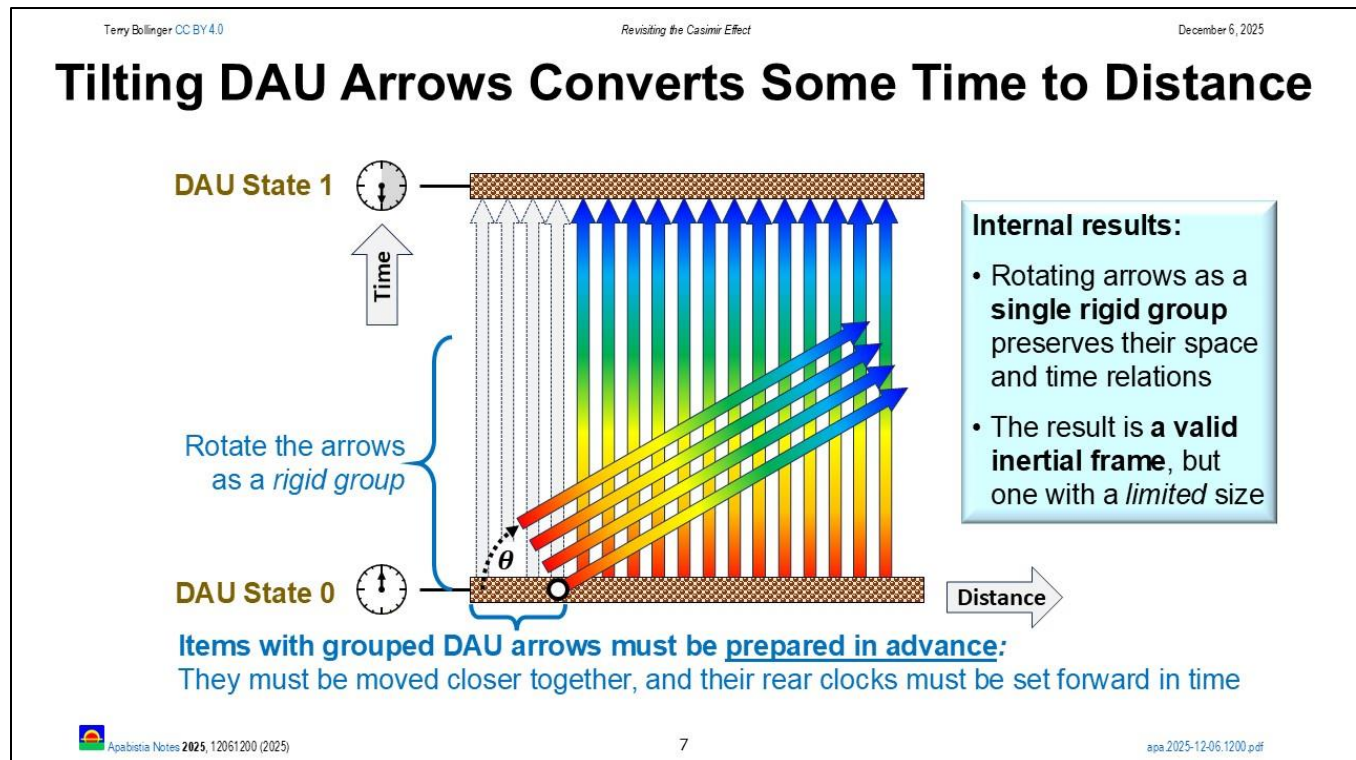
So this simple rectangular representation actually *captures* that quite nicely. It's saying that, yeah, the time stops, but that's not the whole issue. The only way the time stops is if you *convert* all of the DAU iteration the operator becomes *entirely* a distance-like operator, and this was something that the YouTube channel **Ehan Essan** pointed out to me about how there was a simple relationship between space and time and I loved it as soon as I saw it, because this literally converts the concept of space-time interchangeability not into something about hyperbolic surfaces or anything like that, but really just sine and cosine. So, you have a different relationship between the space and time and it always has this very fixed relationship to this invariant arrow (your operator for how you change the state).



[12:23] Here's a more detailed example of that same idea.

You have a cluster of operators. They're all going in parallel. They all start from the same definition. They all have a shared definition of a clock state. They have a time at the beginning, then they have a time at the end (the DAU state 1) and that's the one... but they check their clocks, they do the examination, they find, yes, we all still have the same clocks (clock times). So they say that we have a *shared* definition of what time is and also of what space is. Their separation between them, because the arrows have remained parallel, stays the same.

So, this gives you pretty much a definition of what an inertial frame is *in a state machine model*. So, an inertial frame is simply a bunch of arrows that share the same operator and share the same starting point. That seems like a simple thing, but it's remarkably powerful analyzing more detailed examples of how this works, and to get into an example of that: ...

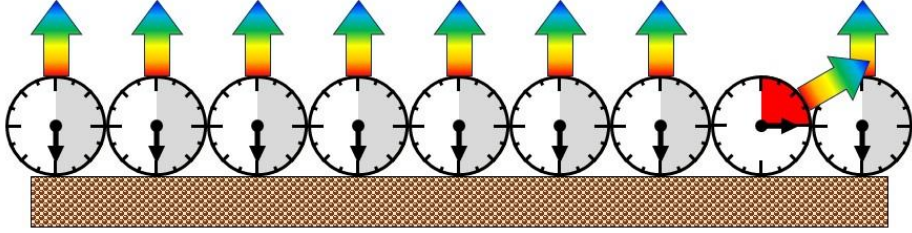


[13:25] ... This diagram, in some ways... I like this diagram, because it's really kind of trivial. It's not a big deal, but it also contradicts, in a subtle way, a century of how we've tended to interpret spatial relativity, and the subtle difference resides in that point... I'm not even sure if I can do... Okay, I don't know if you can see my arrow or not, but that little pivot point (that little round black circle) is over on the front end of some object. It's defined by these four arrows that I have in gray. When you tilt that object you have to actually put these operators up into an angle. You have to do some changes here, so there's a pre-acceleration phase that I'm not really showing here, but it takes some time simply to get these operators in place.

Showing a state machine representation of acceleration just almost immediately (it does immediately) give you much more information about what has to happen to the objects involved and how the process of acceleration works. It is *not* a simple boost. It is something *quite* a bit more complex than a boost, and that's one of the reasons why with this model you can start making some inroads into complex problems where you have multiple inertial frames interacting that you can make more specific predictions (in some cases) of what's going to happen with this.

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

The Universe as a State Machine



The DAU model *is not* a “spacetime” model

- The DAU model is a *state machine* model
- The fermionic universe is the state machine, and is the *only* reality that exists. Physics drives its state transitions.
- Time and space exist only as *transformation operators*

 Apabistia Notes 2025, 12061200 (2025)
8
apa.2025-12-06.1200.pdf

[14:51] So that’s where you get the overall model. You have a universe as a state machine. You have a bunch of clocks that are all going in parallel. They’re all saying, we’re going to do the same thing, but then you have this outlier here, who’s going at a different angle (in this case, a 60 degree angle from vertical) and *that* clock winds up getting half speed, because it’s using a lot of its energy all of its motion through time and space to move *laterally* in the state. It’s *changing* its location in the state machine as opposed to simply iterating within one single place.

So, this is where I say this is not a space-time model. What you have here is you have fermions especially. If you don’t have fermions, you can’t do this. So you can get all the way down to the particle physics level. If you just have bosons... Bosons are part of the time equation, but if you don’t have these gnarly strange little particles called fermions (which is to say, electrons, protons; matter-type particles) you don’t get this property of where you have this nice little separation and this change of state.

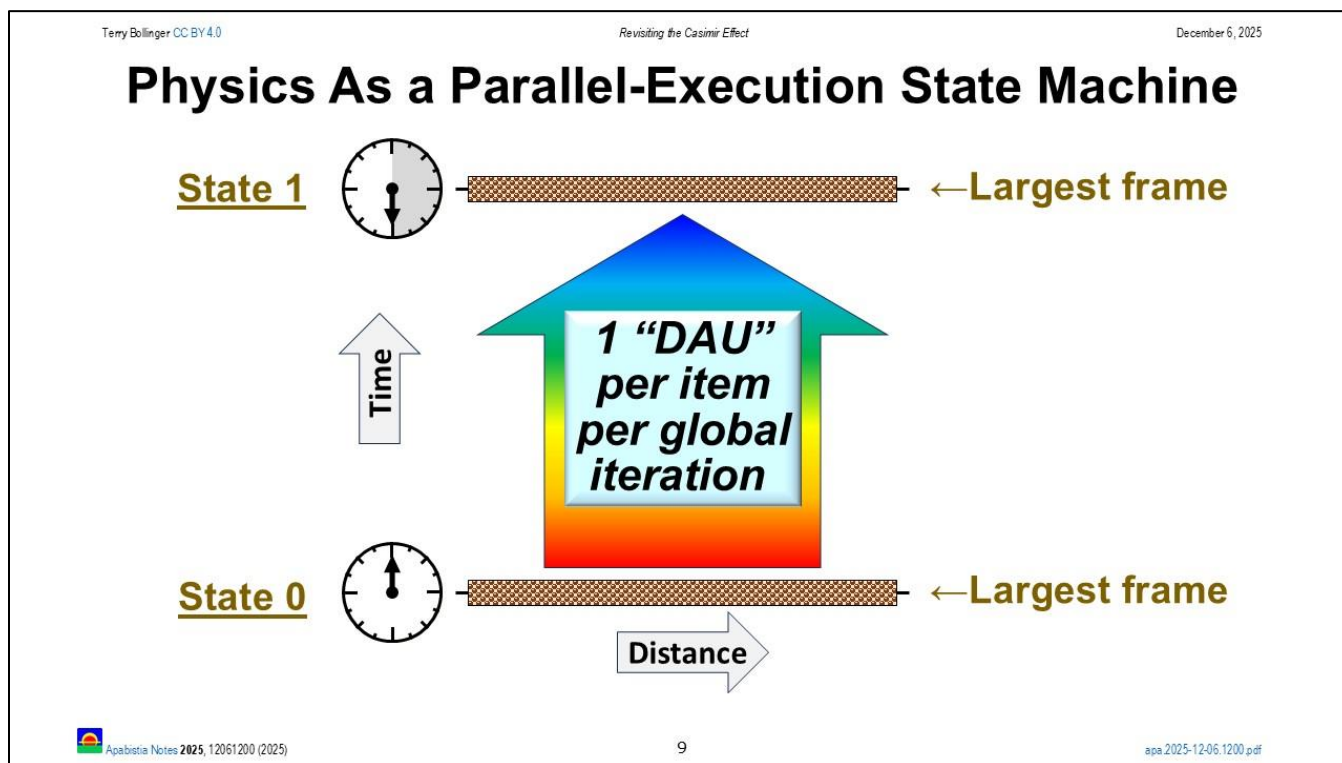
So these become the fundamental units of memory devices. It’s the fermionic states of universes. Those are *very limited* in number. I’ve also had previous presentations on the idea of a sparse information universe. When I say a sparse information universe, when I talk about fairy dust as information that doesn’t really exist, this is exactly what I’m referring to. I’m saying that the fermionic content of the universe defines an *absolute inviolate limit* on how much information you can store in this universe. So, you can create more pairs of fermions, you have a certain amount of energy, there’s some mungability between energy and fermionic memory, but if you don’t have this you don’t have a definition of space or time.

Now that’s (like I said) a *very* different concept from saying that you just have a fabric and then you start playing with the fabric. It says, no, no. It says the fabric starts (*starts!*) and is *defined* and is *limited* by the existing matter in the universe and that all of these concepts that *we* think of as space and time and distance are nothing more than relationships between these fermionic units. The relationships are complex. In fact, I think one of the most *interesting* places to explore this model further is *how* these relationships work between the fermions, how they define in particular the concept of distance, because in some sense they don’t care about distance, which is remarkable, but in another sense they care *very, very* much about distance.

They *define* these relationships and we are trapped within those relationships, but if you talk about issues like *entanglement*, [if] you talk about these strange effects that you get in quantum world, that's where you're peeking below the surface a little bit and you're seeing that these relationships are constructed from the fermionic matter. They're not just a given.

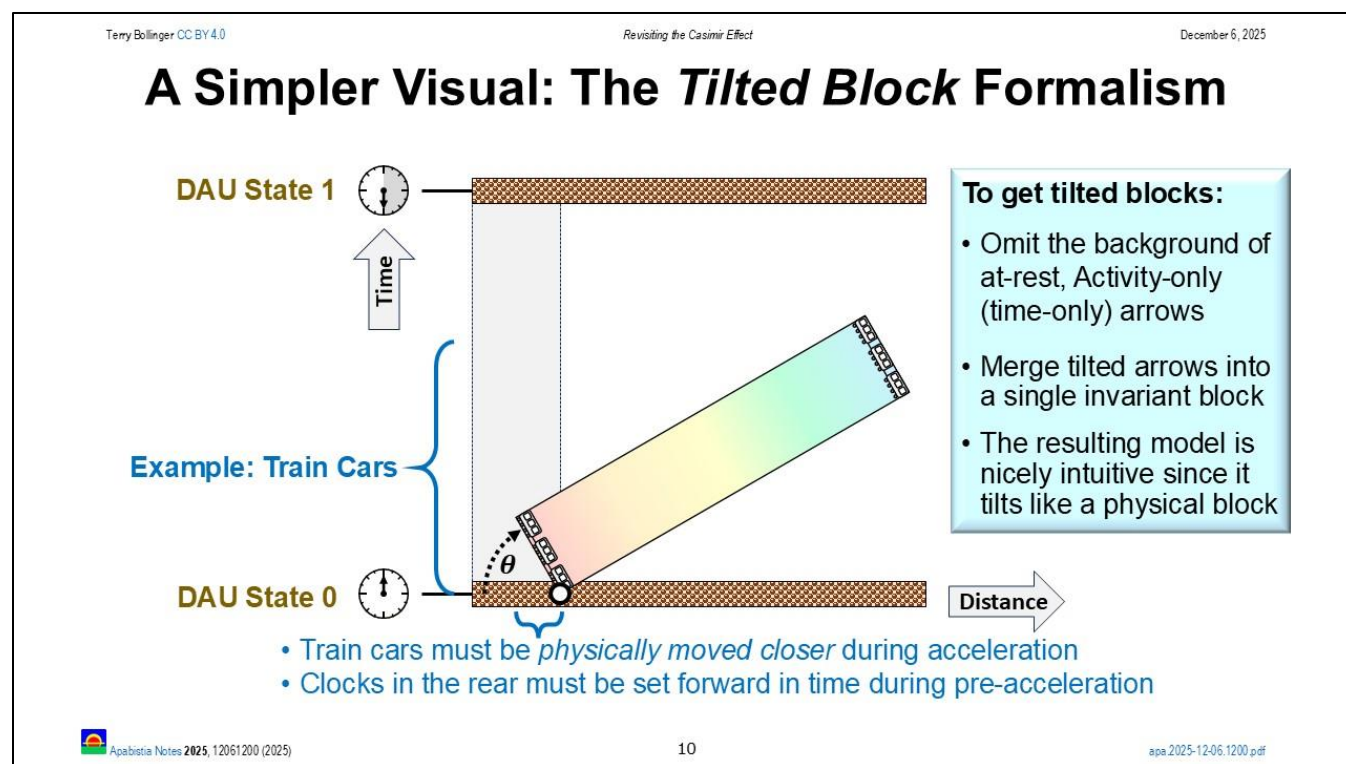
So, again... The universe is a state machine [is an idea that] drives you to the idea that space and time are not just only transformation operators they are finite and limited and scoped transformation operators. You have a certain set of matter, you have a certain set of options for how you can define space and time, and that's it. If you try to talk about space going beyond that, it becomes a meaningless concept. You're trying to do operators on memory devices that don't exist. So you need your memory devices in order to get these concepts of transformation operators.

There's a lot of power in that model. If you think of it as flipping things upside down a bit. You start with the memory devices and then you develop different types of space-time, because one of the things that happens with this model is you have more than one version of space-time. If you go back through some of my previous presentations I've talked about things like the rotational states of space as being actual states of these operators iterating on certain subsets of the memory.



[18:56] Overall structure... It's very simple, very computer science-ish. So you have one DAU per item per global iteration. You can define your DAU unit to be any scale you need, depending on what you're looking at. So you get easy distributions of size, depending on the size of the units. If you have a galaxy, a galaxy is a well-defined unit. You can have one DAU that has a million years as the distance between states, and you can have a million light years as the corresponding unit of the DAU tilted all the way to the right or to the left. So... left to right being all of the possible three-dimensional directions.

So, an *oddly simple* model, but one that puts state machine interaction (state machine dynamics) *above* concepts of space and time in terms of how fundamental they are.



[19:52] There's a simpler way to visualize the same thing. I've used this before.

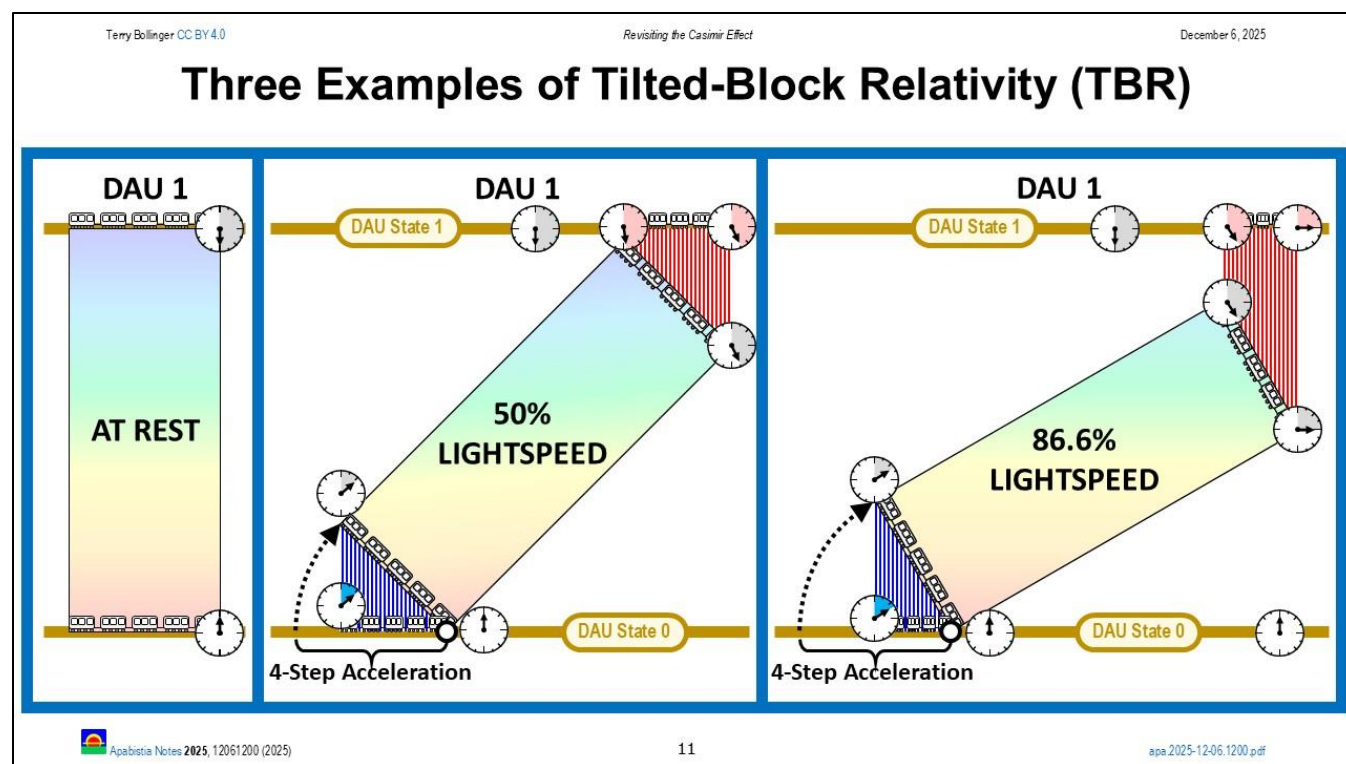
This one, I just like it, because it is *so* easy. It's like playing with blocks. You take that cluster of arrows I showed earlier. You say "Well, you know, I can tilt it one way or tilt it the other.". The *instant* you tilt it, that defines the front of whatever the system is that you're trying to accelerate.

So this is where the idea that the front of the object, the *leading edge* of whatever group of units you're accelerating, becomes extremely important because it then drives the transformations that you have to do on the rest of the units, and again in terms of state this transition tells you *pretty much* everything you need to know just from this little tilted block. Actually, it *does* tell you everything you need to know about Lorentz contraction, about time dilation, and about some other effects that can get a little more exotic, but those are all in there.

One of the more exotic effects is time gradients. You know, Einstein talked about them, but didn't quantify them. This one quantifies them. The tilted block also immediately avoids time paradoxes. Why? Because everything still exists within the same time as the rest of this system. You've still got the other objects moving ahead. So you've just tilted and changed the state of this one *group* of objects. Now, within that group of objects that's where you have the *remarkable* ability to define a space and time in which no experiment can tell you that you're not the same as anybody else.

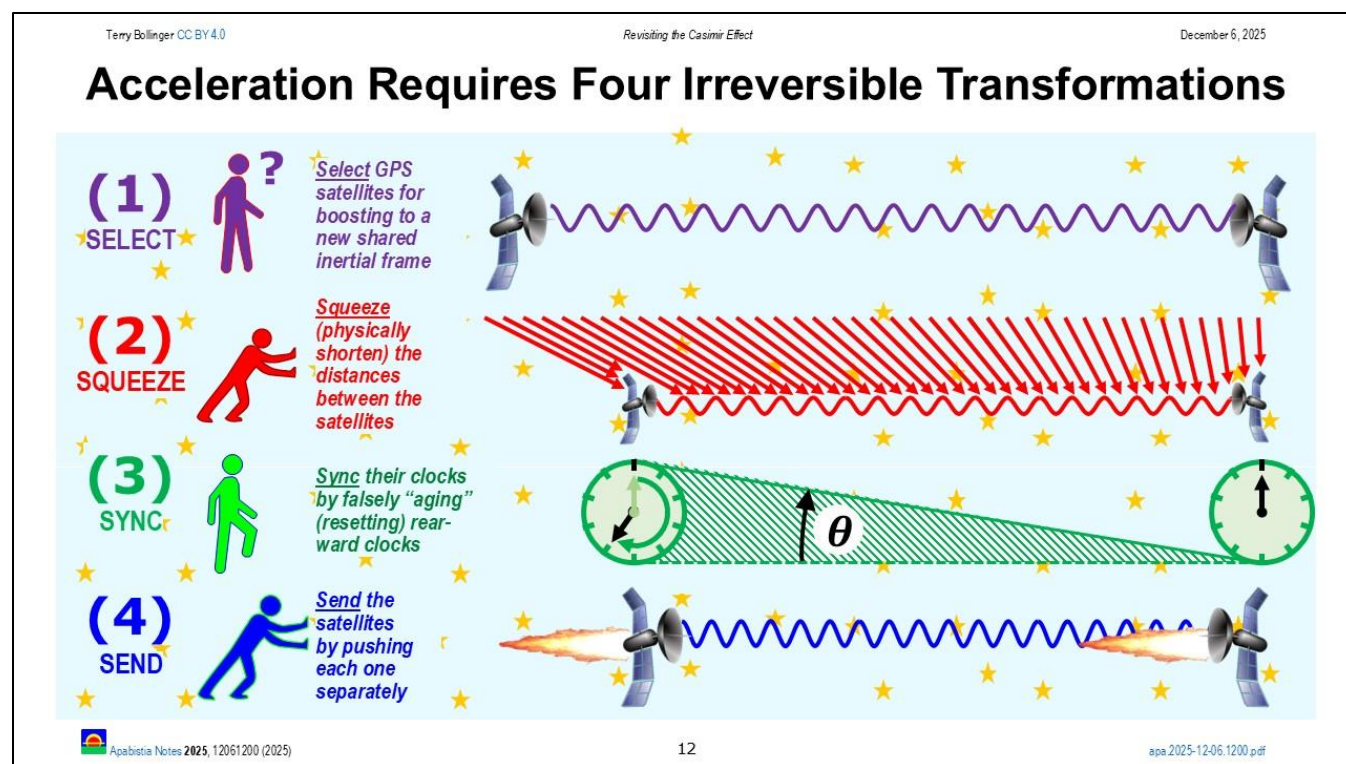
This is the old equivalence between inertial frames. *That's* still there. What the state machine model does is it says "No, no, no, no. You *can't* just extend that arbitrarily. You *cannot* just say it applies everywhere.". You can create these new space-times that have these marvelous properties, but they're also finite in length. So you tilt three cars on a train. You accelerate the three cars on a train, you sync them all up. That's all you get.

Everything else becomes relativistic Doppler effect. Everything else becomes just how you interpret the outside data. You're not changing the outside universe, which in many ways is just common sense to say "Well, because I accelerate it, I don't *change* everything else. I don't slow down the rest of the universe. The rest of the universe could care less what *I've* done.". The operator dynamic (tilted block dynamic) immediately shows you that.



[22:21] Here's just three examples of that, and this is again where I point out that these tilted blocks are remarkably powerful for telling you what the transformations are. You find out that when you accelerate the object you *have* to begin with a set of clocks that have certain values and these values correspond to the *locations* in the *embedding space*. You have this embedded space that *still* has the same time and space definitions as ever. You're the subset. You're the guy *embedded in* that space. So, the train embedded in that space follows these rules, sets this up, and here's the kind of results that you get.

So after one DAU for *this* group of objects, you wind up with these different results. So you find out that you have your non-simultaneity of the front and back of the train. You have your Lorentz contraction, because you actually change the state where these things have to be smashed closer together, and the exact amount from the tilted block is the same thing you get from the relativistic diagrams it's just simpler math, which is a little bit of a hint. The fact that your math simplifies that much and you get exactly the same result, you want to pay attention to that because it's saying something about maybe you don't need the hyperbolic stuff, maybe you don't need quite as fancy of a structure as you thought.



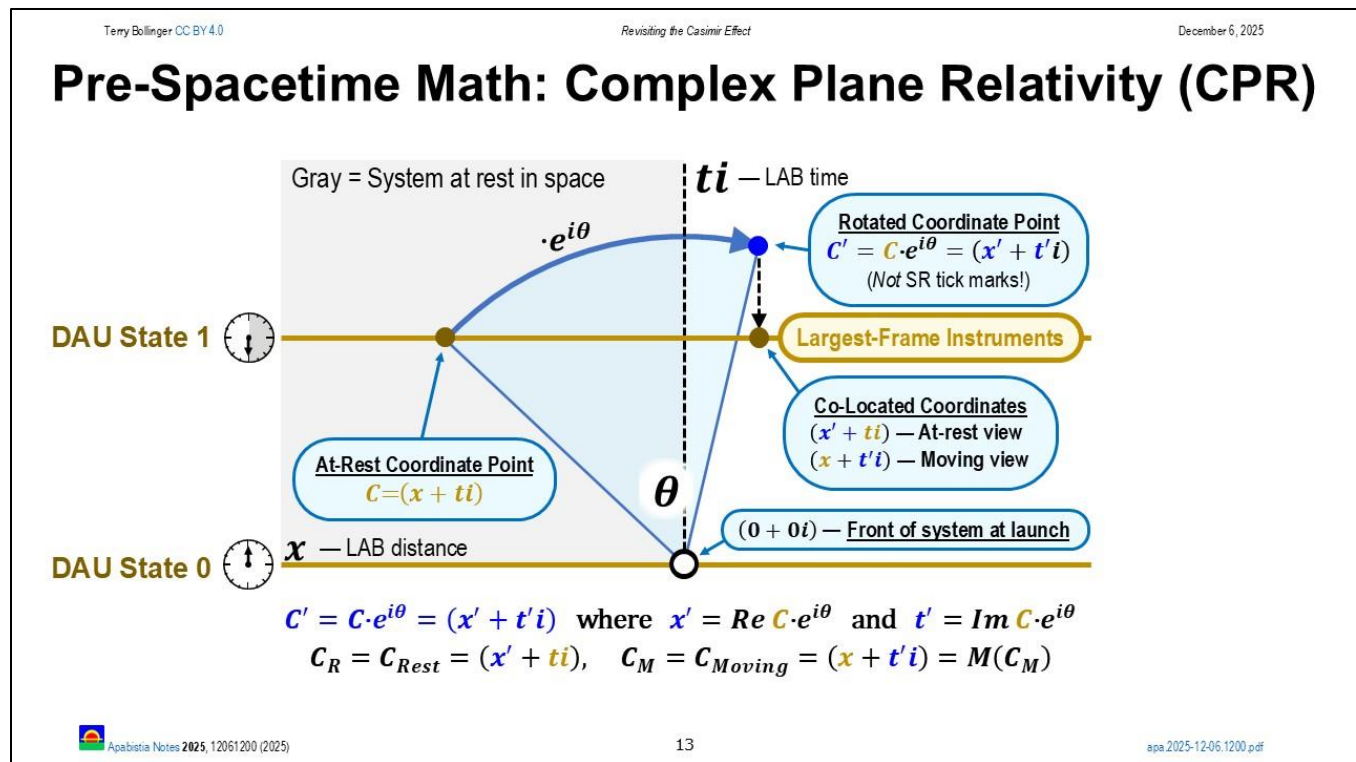
[23:40] ... This is the one that I've shown a number of times and will *continue* showing, because it is just *so* important to understand this. Acceleration is *not* just a boost. Acceleration is not just a second derivative. That is an oversimplification of the math. You *must* look at the physical state changes that happen in the state machine. This is why I say state machine representation is *more powerful*, because it tells you what you have to do.

You have a selected set of objects, *finite* (that's an irreversible choice once you make it). You have to *physically squeeze them together*, and if you do it in satellites it makes it *really* apparent. It's not something that you can... When it's a small object it's easy to fool yourself into saying that "Well, it's all just a transformation of state.". It's not! If these satellites are a light year apart it can take you up to a light year to get them in the proper position and *all of that* has to be taken into account before you can actually accelerate the object, which is *remarkable*. That's not just a simple smooth differential boost. That's something much more complicated.

You *have* to reset the clocks and the example I've given before (I always find this amusing) is that it's *no* different from setting clocks when you have daylight savings time, where you go one way or the other, depending on which season it is. You move the clock ahead in the back of the train, and this is *so* literal that you could actually have (in a large enough train, with a large enough acceleration) an actual human being in the back of the train physically adjusting the clock and say "Okay, it tells me now that it's 1 o'clock and it was 12 o'clock.".

That's weird and because *he* didn't see an hour go by, he just reset the clock, and it's important to understand that difference because that's where the time paradoxes disappear, because you realize that the elapsed time is still *exactly* the same as the embedding frame. You haven't lost... you haven't created new time. You haven't taken time of out somewhere. You just reset the clocks, and then the final stage in this one is to actually send it, to actually accelerate.

So again, easier to show with satellites, because in satellites you *do* have to independently accelerate them. If it's an actual train, you're pushing it so it's easy to skip over that "detail", but these are *not* details. These are *fundamental* to how this works, and the state machine approach shows that, shows it very clearly. A differential mathematics only model makes it *so* easy to skip over these critical steps.



[26:25] When you take this structure... and this one I've talked about before (talked about it last time), but this is moving in interesting directions and fairly quickly. I did not know that there was an imaginary plane representation of this until I was going through the math and coming out like "Oh, all of this is just one complex number multiplication, or rotation, in complex space.". *Really?* And it's kind of like "Okay, *how* did that get so simple all of a sudden?" and yet that is what you're doing.

This is essentially a tilted block diagram, picking in on a single point, and then translating it into to imaginary real-time real coordinates. One of the things I'll be experimenting with in the future is I think there's a *very, very* interesting quaternion connection. If any of you listening to this are quaternion fans, *you* should take a look at this, because quaternions have been frustrating people in special relativity for literally I think a century (almost a century) because they *seem* like they're the right idea, but they're Euclidean and of course you had this whole thing about Minkowski's signature with the mixed signature. This flips everything back into Euclidean.

So all of a sudden, the idea of quaternions to represent the three directions of space and then in that case this real axis... this time axis would become the real axis, because you still get the same rotations. So there's a fascinating potential here to use quaternion math and also octonian math, for those of you who are into that sort of thing. Octonian math *also* has some *really* interesting prospects because it includes the idea of momentum space.

So, I'm going off on a little math tangent on this, but there's just some *really, really* interesting mathematical possibilities for exploration in terms of representation of the state changes of the machine and they involve mathematics that many people have *tried* to use for a long time and had mixed success. Sometimes it seems to work, sometimes not. I think part of the reason why they haven't worked is this bit of confusion about the mixed signature Minkowski space.

Is SMU a “Simulated Universe” Model?

➤ Nope.

- Despite its use of the computer-compatible state machine model, **SMU does not postulate a separate substrate executing the model**
- Instead, SMU asserts that physics exists because what we call **matter and energy are organized as a state-machine structure**
- The SMU dependence on matter for state storage means:
 - “Now” as defined by the SMU is the *only* reality (**no block universes**)
 - There is *barely enough storage for one universe* (**no multi-worlds**)
 - All quantum phenomena involve loss of spacetime detail (**fuzzy spacetime**)
 - **Quantum Field Theory needs a full rewrite** (but with the *same* predictions)



[28:40] Is this a simulated universe model? I’ve just been... I’ve been talking already to say “This is all just like a computer! Yeah.”. Well, *no!* It is *not*. In fact, it’s really *very, very* different from simulated computer models that pretend that there’s a computer somewhere. This *is* the computer. The state machine *is* reality itself. You only have one instance of it. It’s not running on some separate substrate. It *is* the substrate. It *is* the state machine. It is the set of rules that apply that you get these transitions from one state to the next state, one DAU (one DAU iteration each time).

So, that’s not the same thing as a [simulation]. A simulation implies that you can have a universe on top of a universe and there’s a *really* dangerous assumption in the simulated universe idea that information’s just free. Wee! You know, just any information you want, because space-time’s infinite (infinitely detailed). You can get all these *silly* ideas that don’t correspond to anything experimentally, because we *never* see that. We *never* see infinite information experimentally. We only see quantum uncertainty after you’ve run out of energy, and it’s an important feature to keep in mind, because if you *assume* that there’s a space-time fabric, and you *assume* it’s completely continuum-smooth then you’ve assumed infinite information.

We *don’t* see that experimentally, ever. Quantum always puts a limit on that and it’s trying to tell us something important. So, you get this state machine structure and [now] you get no block universe. You’ve only got one universe. You barely got enough storage for one universe, because the fermions that are out there that you can count: that’s it. That’s your substrate. That’s your state, and once you run out of those, once you run out of the energy and the fermions that you have, you *don’t* have any ability to create any more information and therefore no ability to create more... either to extend this universe into a block universe (make these things infinitely long). You also don’t have multi-worlds. You don’t have enough *information* for multi-worlds. It just doesn’t *happen* in a state machine model.

Anything that involves loss of space-time becomes this quantum domain, so there’s a relationship between loss of information and quantum. It’s more complicated than that. There’s some *really* interesting stuff going on, especially given issues like entanglement, but you have to realize that you’re hitting a hard limit whenever you get quantum. You know, the reason an electron can’t figure out where it is around the atom is *not* because there’s an *infinite* number of electrons doing *infinite* things at *infinite* times and *infinite* ways, which is if you think about it a



little strange. *Why* would you think that? But it's just saying that that's the best the electron can do with the mass and energy it has. It doesn't have enough mass to get any sharper than that.

An electron orbital becomes pretty much the best definition of a localized electron you're gonna get. You can have a stronger positive charge and make the orbital smaller but it's always going to look something like an orbital. So it's a different way of looking at that. Instead of filling that space with particles that all take infinite energy to actually instantiate. You just say that doesn't sound right. Let's stick with the energy you have, stick with the detail you have, and realize the fuzziness is due to *lack of information*.

The state machine cannot make something that it doesn't have enough memory to define. Unavoidably, quantum field theory... if you take a state-speed approach quantum field theory gets hit the hardest, and that doesn't mean that quantum field theory is in any way... Well, no, I'm gonna qualify that. Quantum field theory is one of our best theories we have for predicting any of a number of phenomena. QED is *amazing* what it can predict, but this thing... but even *Feynman* was saying that he said it's probably more like a checkerboard. It's something, you know... and he derided his own theory just to make this point. It's that something's not right when we put infinite energy, infinite mass, infinite information into one cubic centimeter of space.

So, one of the *consequences* of that, where quantum field theory does *terrible*, is the vacuum density issue, because quantum field theory just has *no* answer for that. In fact, it just makes some of the most terrible predictions in all of physics. So, what you need to do is quant—... Somehow quantum field theory has to be rewritten in terms of the state machine formalism and I think that's a fascinating issue because you still have to... You gotta keep the same predictivity that you have. You don't *lose* what you get in quantum field theory, but you do have to take a different look at it, and you can't just keep elaborating details infinitely down at the bottom.

Does SMU Mean Space is More Fundamental than Time?

- No, but SMU requires a very different interpretation of “distance”
- Without “space,” separation of local states (units) cannot occur
- Just as time emerges from “looping” of an irresistible direction of change, distance emerges from state-isolating forms of looping
- The same effects that give rise to well-separated radio frequencies give rise to well-separated states that we think of as “distances”
- The role of *momentum space* (reciprocal space) is critical:
 - Location space and momentum space form a *broken symmetry*
 - The severe compaction of momentum space enables vast “space” distance
 - This is one of the most intriguing future topics for the SMU model

[33:37] Now, if you notice on the model (SMU model: state machine universe), [it] uses space as a separation and then time becomes an aspect of that. So does that make space more fundamental in time? Definitely *not*. The definitions of space are themselves some kind of subtler, more internal looping behavior that are... is going on

and is allowing these things to separate themselves on a frequency basis that doesn't involve a whole lot of energy.

When we use frequencies in regular energy, like an electromagnetic spectrum, there's a strong energy component to the frequency separation. Whatever's going on with the separation of the states, of the fermionic states in terms of space, the marvelous property of it is it's *almost* (not quite) but *almost* energy-free. So you can have this *incredible* separation at almost *no* cost whatsoever. So you have this very weak bonding at large distances, but you don't have an enormous amount of energy involved with that.

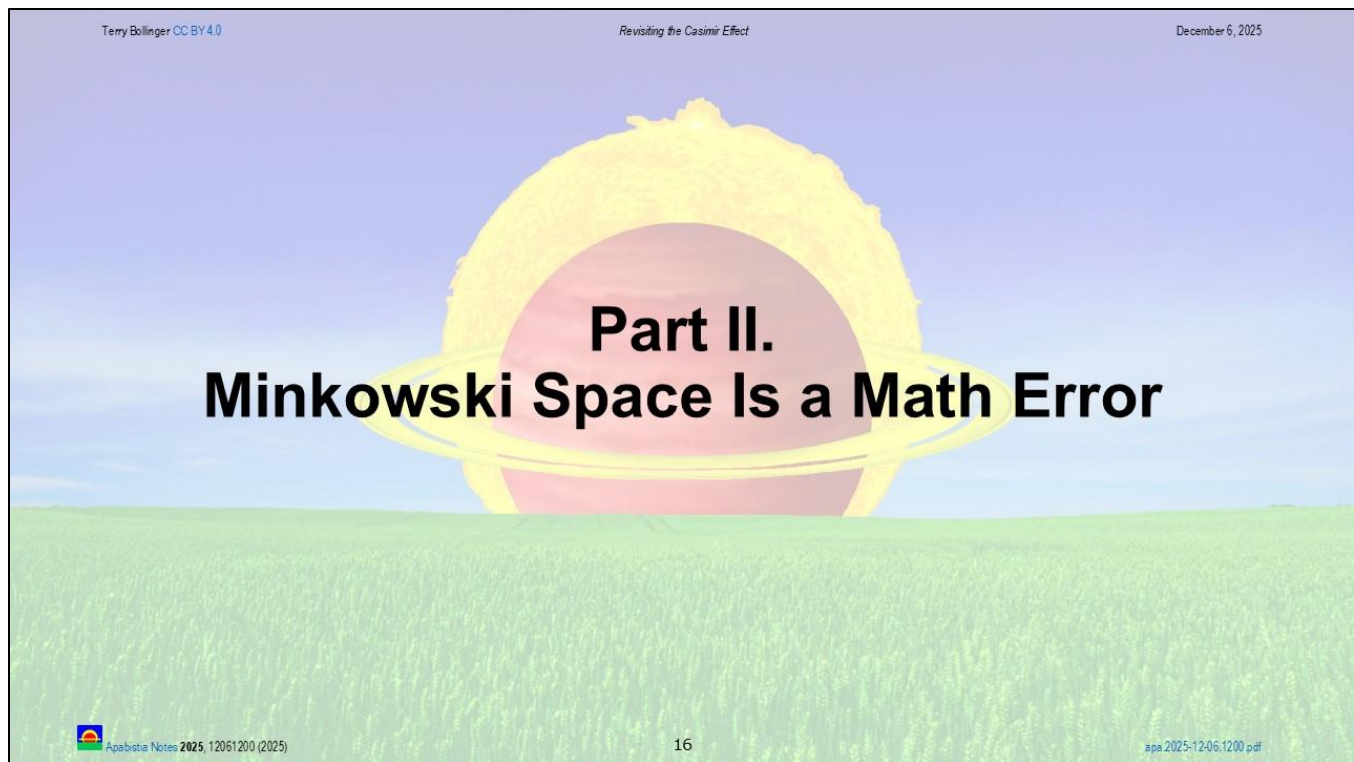
That's really what made our universe possible. It's that you could have this kind of *extremely* cheap separation [that] allows this instantiation of a *state machine*. So there's some *really* interesting physics that go on. So same idea of radio frequencies separate these states, that they have different, you know... they're actually different frequencies. So when you have an object at some distance from us there is a frequency and separation interpretation of that, and we see this in physics all the time, where you always have this reciprocal interpretation of distances, but the *cheapness* of it is what's really remarkable for the space domain.

Postulate... (and this is actually an old postulate that I've made, oh gosh, over a decade ago? I don't remember, a long time ago), but the state machine model just makes me want to emphasize it that much more.

You have two spaces that are used in physics (especially in quantum physics) which are the location space with time, and then you have the reciprocal space (the momentum space) with mass and energy. Somewhere in here [{gestures, enclosing a volume}], somewhere in those two, which probably have some kind of octonion representation if you're into hyper-complex numbers... somewhere in those two there's a break and one of them *collapsed* and becomes *localized* into the energy and momentum component of objects, and the other one *expanded* and became *massive* and was able to implement this idea of very, very, *very* cheap separation.

So, within this concept of these... essentially a total of eight spaces (the octonion space is the most likely mathematical structure) you have a fascinating symmetry break, and that symmetry break is fundamental to how we go about doing this. This is a good op—... This is a good topic for exploration. Going to a state machine model does *not*... It *changes* the type of math you use, but boy it gives some interesting opportunities to some [mathematics] that people have tried and maybe need to try again from a different perspective.





[36:52] Minkowski space is a math error!

Oops, did I really say that? Yeah, I did.

What Happened to Minkowski Space?

- All of the Poincaré/Lorentz transforms *still apply*
 - Creating a new inertial frame creates a new definition of space and time
 - That definition is as *valid internally* as any other spacetime definition
 - However, the new definitions apply *only* within the created inertial frame
 - Non-trivial scoping (acceleration tracking) eliminates *all* time “paradoxes”
 - Multiple spacetimes apply to every subset of the largest available frame
- The negative time signature of Minkowski space is a math error
 - Leonard Susskind described beautifully why the minus exists:
L. Susskind, *The Proper Time Invariant*, in *Special Relativity Lecture 1*, Stanford (YouTube), Apr. 26, 2012. <https://youtu.be/toGH5BdgRZ4?t=1h31m21s>
 - The error (Einstein): Assuming frames can always share the same origin

[36:58] Minkowski space is *not* an error in the sense that all the Poincaré-Lorentz transformations... those still apply. You can go to that new space (that accelerated space) and *within that space* you can readjust all the coordinates so that you see your own orthogonal definitions of space and time and they're just as good as anybody else's. So those still apply. There's no problem with that.

However, the negative time signature of Minkowski space is... the only way to put this is it's a math error. It's *not* fundamental. It is *not* correct. It produces *all* sorts of consternation and you start doing these Zen-type operations about saying, like, you know "There's no distance between things if they move at the speed of light, even though obviously they're very far away if you move at the speed of light." So, you get out of that... and the reason those things pop up is the way that the Minkowski space negative signature was derived... and Leonard Susskind has a *beautiful* description of this. He really is... I *highly* recommend this little section.

He's a *great* speaker on these topics and he gives an explanation about saying "Well, here's what happens: You *assume* that it's Euclidean. You *do* the transformations that Einstein created, and here's what happens." It no longer cancels and he shows how you *have* to use a negative sign in order to get it canceled and suddenly you come out with the right math. There's a *problem* and actually Susskind states it right at the beginning when he shows his first figure in that YouTube session. He shows the *origins* having the same origin, and you go like "So what? So what's wrong with having the origins at the same place? You can put the origins wherever you want to, right?". No, you can't, and that is what's so *beautiful* about this error, because it makes it *so* subtle.

Terry Bollinger CC BY 4.0

Revisiting the Casimir Effect

December 6, 2025

Einstein's Subtle Shared-Origins Error

- To derive his inertial frame coordinate transformation equations, Einstein assumed in 1907 [1] that one can:

"... choose as the starting point of time in both systems the moment at which the coordinate starting points $[(t, x, y, z)=(0,0,0,0)$ and $(t', x', y', z')=(0,0,0,0)$ coincide;"

- This violate the tilted-block principle that time resets must place the zero point at the *front* of the tilted block to prevent time paradoxes

[1] A. Einstein, *Coordinate-Time Transformation* [Sec. 3, pp. 418–420, in 'About the Principle of Relativity and the Conclusions Drawn from It,' pp. 411–462], *Jahrbuch der Radioaktivität und Elektronik* **4** (4), 418–420 (1907). See Section 3, page 418. <https://sarxiv.org/ref.1907-04-04.0418.engl.pdf>



Apabistia Notes 2025, 12061200 (2025)

18

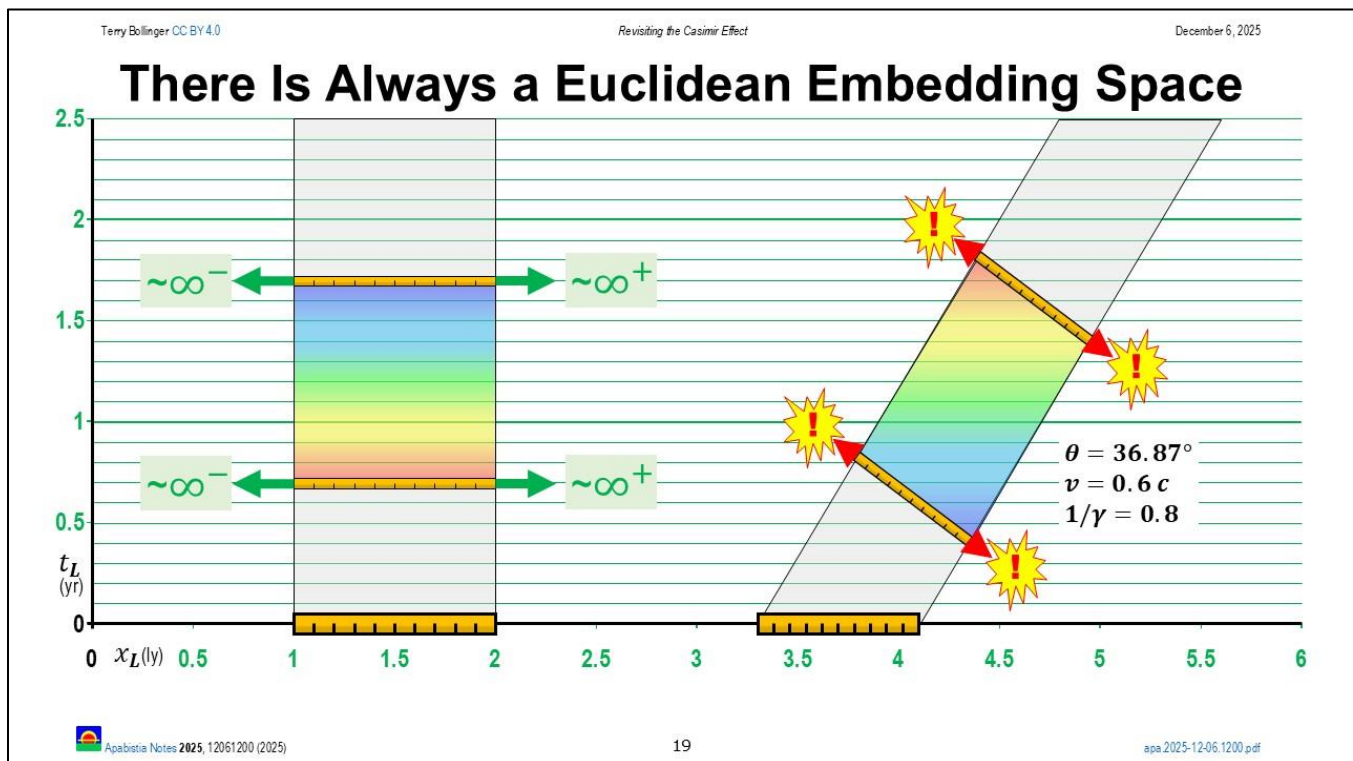
apa.2025-12-06.1200.pdf

[39:01] Einstein said (back in 1907) that you *choose* a starting point in both systems the *moment* at which the coordinate starting points coincide. The instant Einstein said that he hosed himself. He hosed himself for the rest of his life, because by making that assumption he created time paradoxes and if you think of those blocks I was tilting earlier, tilting the block into the past. As soon as you do that you're putting the... It's got a little origin, you're taking [it and you're putting] it in the back end of the block and then you're pushing the block down this way until it intrudes into the past, and you can't do that without violating causality, so what seemed like an innocent assumption that is a very standard mathematical assumption...



You've got two coordinate systems, *surely* they can coincide. Turns out to create a paradox that you really then can't get out of, and because it's such a subtle error it makes it very hard to realize *why* it didn't work, and you see this in Einstein's own work because he never put clocks at the beginning and end of his trains. I've said this before, but Einstein would put clocks everywhere, except for that bloomin' train of his. You know, he had this train going by at almost the speed of light, and he wouldn't put a clock in the beginning and the end of it. He just kind of skipped over that part, and this goes back to this point, because once you make this assumption it gets *very* ambiguous how you define clocks, how you correlate, how you start the clocks.

You can say how they change but you can't say what the original settings are. Tilted block formalism gets rid of that and just says these... this is just time shifts. This is just daylight savings time stuff. There's nothing profound going on here. You just have to do it, because otherwise you can't create the new construction of operators that will then give you space and time-like behaviors.



[41:01] You can see this as kind of a graphic example here [{referring to the slides}].

These are some of the tilted blocks. They're also very similar to some of Minkowski's figures, because he also used these trapezoidal blocks if you look back in his original work. You have one frame over here on the left. Now notice, *because* that frame has used the time-only definition of going between the iterations, that one on the left has no problem synchronizing with literally the rest of... I mean this could extend out to the Andromeda Galaxy. The Andromeda Galaxy is not moving very fast compared to us.

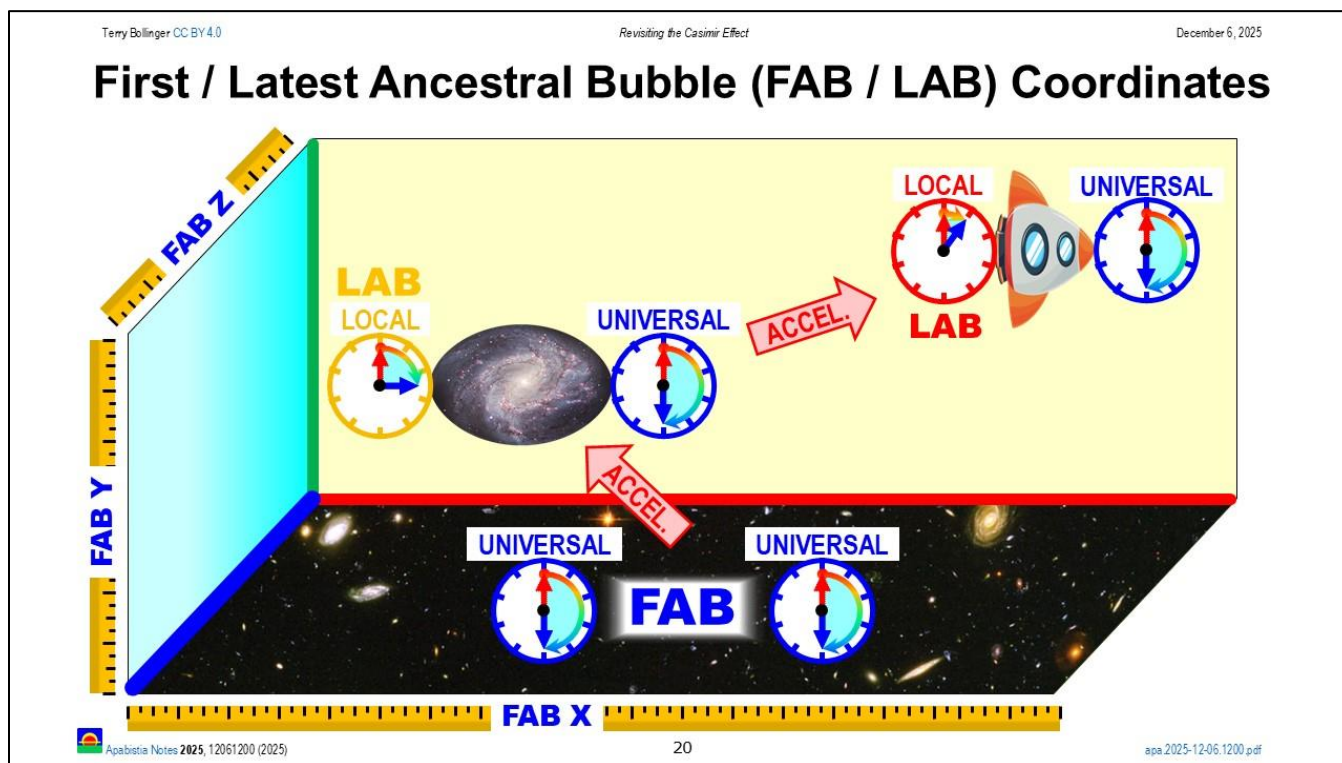
So you have this *huge* domain in which those time definitions apply. Time definitions depend on *not* moving relative to each other, not how far away they are, but *not* moving. So if you've got two objects that are *not* moving relative to each other and they're 10 galaxies away from each other it doesn't matter. You can consider those to be part of the *same* inertial frame. So it's a little subtle point that you want to be careful about. That how... you know... How large is the area of things in which you have things that *share* that commonality?

Now, if you just accelerated your *ruler* on the right, which could be that train again, all of that is lost. At the boundaries you get *bang*, you lose that. At the boundaries, all you can see is the other coordinate system. You

can... you lose the ability to extend those rulers beyond that scope, and that's important because it says, again, the tilted block is a *finite* limit on how far the inertial frame applies, but the *more* important point, and this gets back to, again, I loved Leonard Susskind's talk about invariance. He said "... but you need an invariant. How do you create an invariant? How do you create a number that doesn't change?"

Well, the answer in this case is *extremely obvious*. It's you use the larger embedding. You use the space in which the object is moving, because you see those horizontal green lines? They still apply. You can still measure every one of those points and those rulers that are in motion. You can still test every one of them. We usually *don't*, but you can and the results as you get, even if you don't, are going to be the same.

So, you have a coordinate system in which you *do* have Euclidean definitions of space and time, which is what this figure is. I've got X along the bottom. I've got time going up. This is Euclidean space-time. So that Euclidean space-time can record these events and *that's* where your invariant is. So the idea that Susskind brings up about how you have an invariant distance you define in an Euclidean way no longer seems to apply. It *does* apply as long as you use the larger embedding frame. You get hierarchical space-time. You don't have just one continuous spacetime for each unit. You have a hierarchy. If you accelerate something, you've created a subset, but the outside definitions still apply.



[44:02] By the way, I *have* added some slides from the set that I had last night. If you're following along in some slides, a warning: You might want to download a new set. I've added five slides and these last two have been a couple of them, but just to warn you in case you're like "Where'd that slide come from?". So, this gives you this idea, if you extend it large enough, that you can really go all the way back to something approximating, you know, the cosmic microwave background. The whole curvature of space is a whole other issue. I'm not trying to address that in here. The point is that you have Euclidean definitions that can go over *extremely* large spaces of many, many galaxies, and you can have at least a concept of the first ancestral Poincaré bubble. That is: a set of a first inertial frame bubble that has all these shared definitions.

Well, *guess what?* You can *use* that at whatever level you're at to do your Euclidean invariant measurements of the separation between different events. So, *we* do that in a more *localized* sense. We have your local... your

latest ancestral bubble (or local, you can call it local, but I like to say latest) and the last one that everything shares a common definition from which they accelerated. So you can use that LAB bubble and you can make all the definitions and create Euclidean four-dimensional space to track what the events are and to say what the distance is between them. Now, do people actually use that? *Of course they do!*

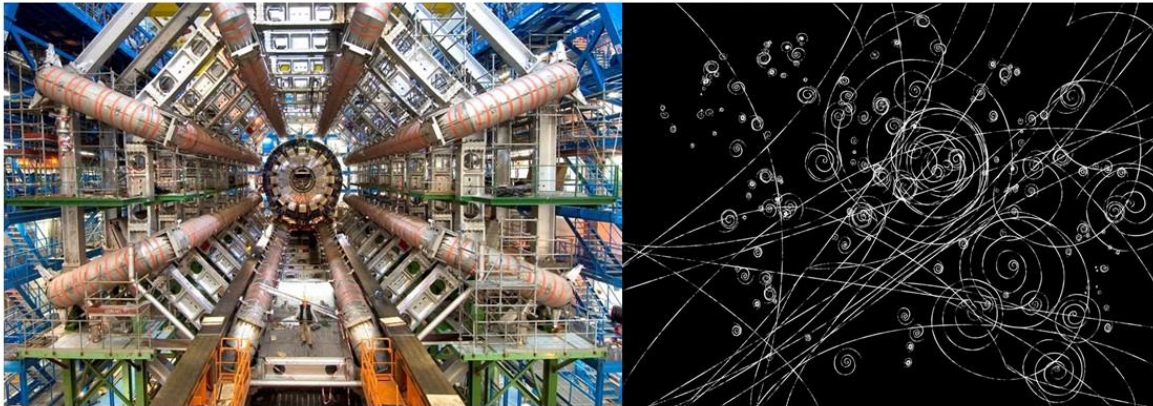
Terry Bollinger CC BY 4.0

Revisiting the Casimir Effect

December 6, 2025

Real-World Examples of LAB Euclidean Invariants

- Question: Are Last Ancestral Bubble (LAB) viable experimentally?
- Answer: Of course they are. CERN uses them to record its data.



Apabistia Notes 2025, 12061200 (2025)

21

apa.2025-12-06.1200.pdf

[45:39] You know, it's intentionally being a little humorous. Do people use LAB coordinates? Well, have you ever looked at a bunch of particle tracks from CERN? You're not looking at them in Minkowski space. If you tried to translate that figure to Minkowski space you'd be spending the next century for each one of the particle tracks on each acceleration trying to redefine what the definition of space and time and invariant is. *Of course* we don't do that! What we do is we take a picture of it *in the embedding space* (the LAB space), which is Euclidean, and then we have a *location* of the track. We have a *time* of the track. Everything's Euclidean. There's no Minkowski. You don't *want* Minkowski's space. It would be a horrific task to try to translate this and you wouldn't get anything out of it, and again, why is that? Because the Minkowski space is fundamentally a result of a mistake, a small subtle error that you could effuse origins instead of acknowledging that you have to create subsets. So if you don't have the subset concept and your state transition machine you can't get this right.

Minkowski and Differential Geometry

- Another problem: In a state machine formulation, Minkowski's "substance" hypothesis disappears entirely:

"To never let a yawning emptiness, let us imagine that everywhere and at any time, something perceivable exists. In order not to say matter or electricity, I will use the word 'substance' for that thing."

— H. Minkowski, Space and Time. 80th Assembly of German Natural Scientists and Physicians, [Sep. 21] (1908). <http://www.minkowskiinstitute.org/mjp/books/minkowski.html>

- Minkowski used this assumption to argue that special relativity is a purely geometric concept based on his lengthy "world lines."
- Important implication: Differential geometry is *not* the foundation of the universe. Like spacetime, differential geometry only *emerges*.



[46:52] I'm gonna pick on Minkowski again [and his] differential geometry. ... Okay, this is supposed to be physics, folks. ... [But] sometimes physicists just kind of [fall into the approach] of saying, "I'm just gonna say something!" And boy, is this ever an example! "To never let a yawning emptiness, let us *imagine* that everywhere and at every time *something perceivable exists*."

What?! What?! Where'd he get *that*? Where did *that* come from?

If you said that [for the three x, y, z axes of] space, you would make every particle into a giant block that occupied all of the universe! Why do you get to do it with *time*?

And he uses this word "substance." This is a *preference* — a philosophical preference — and Minkowski just *jammed it in*. There's no [experimentally meaningful] definition of this [concept] that corresponds [to this concept] of "never let a yawning emptiness." That pretty much summarizes [what happened:] He just *said it* that way.

Why did he do that? Because he wanted differential geometry. He was just *burning* [to get differential geometry into the mix.] He just *really* wanted differential geometry, because that was kind of his baby, and this allowed him to create world lines.

Once he had world lines he could talk about differential geometries and about the shape of it. This is a valuable mathematical concept. That's not the issue, but the issue is if you try to make it fundamental by *adding substance that's not there* then you're actually *redirecting* from the structure of the universe *as it actually is observed*. So this is an extension based on preference. This is not an extension based on anything experimental. The implication of this though is that even though differential geometry is just so [important]... It's incredibly important, and also like in things like solid matter physics, where you've got plenty of detail available, there's just *marvelous* things you can do with differential geometry.

However, if you're talking about the smallest units, the most fundamental units, the most isolated units, the lowest mass units, you need to be careful, because differential geometry is going into the state machine. You're using differential geometry when you should be using *finite state machines with limited resolution*, and those are very



different things. In differential geometry, just like space-time... emerges from this state machine, not the other way around. You don't start with differential geometry and then the state machine comes from it. Nope. Other way around. You get this set of operators that cooperating together *produce* these differential geometries that then become the power that we see in classical physics.

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Einstein v1 on Minkowski's "World Lines" Relativity

Einstein was *not* happy and *not* afraid to say so.

"When, later on, Minkowski built up the special theory of relativity into his 'world-geometry,' Einstein said on one occasion: 'Since the mathematicians have invaded the theory of relativity, I do not understand it myself any more.'"

— A. Sommerfeld, *To Albert Einstein's Seventieth Birthday*, in 'Albert Einstein: Philosopher, Scientist,' P. A. Schilpp, Ed., in 'The Library of Living Philosophers,' Volume VII, Open Court, 1949, pp. 97–106. Page 102.

Valentine Bergmann on what Einstein told him about the tensor model: "Superfluous learnedness"

— A. Pais, *Subtle is the Lord: The science and the life of Albert Einstein*, Oxford University Press, 1982. Page 152.

Minkowski: "With a hardy piece of chalk I can draw four world axes on the blackboard."

— H. Minkowski, *Space and Time*. 80th Assembly of German Natural Scientists and Physicians, Sep 21, 1908.

Einstein, in a lecture about special relativity shortly after Minkowski's talk: "This has been done elegantly by Minkowski; but chalk is cheaper than grey matter, and we will do it as it comes." [Ouch!]

— George Pólya attended the lecture and reported the comment. Béla Bollobás reported Pólya comment in his *Littlewood's Miscellany*, Cambridge University Press, 1986. Page 152 (yes, same page number as the Pais quote).

Apabistia Notes 2025, 12061200 (2025)

23

apa.2025-12-06.1200.pdf

[49:37] Minkowski... There's two Einsteins. There's Einstein version 1, who felt bad... Minkowski unfortunately died very abruptly of appendicitis, and Einstein felt terrible about it. One of the reasons why Einstein felt terrible about it was that he had said some pretty blunt things about Minkowski. [A] famous [example] was... It's not the most famous one, but the one that I thought was the most *pointed* was the last one where Einstein made a casual comment that Minkowski, when he made his comment about with a piece of chalk I can draw forward axes, Einstein essentially called him "chalk for brains" for saying it, so... *Ouch*, you know, Einstein was not happy with this. He was using clocks. He was using a much more digital approach. He was saying if you don't have a clock, if you don't have a ruler, it doesn't make sense, and Minkowski took it in a totally different direction, and then ironically to history they later converted, but Einstein was not real keen on this world lines idea *at first*, at first.



[50:42] Now, I'm going to put in... enough of that. I've already... I've grouched about some of that in the past, but again, this is something that physics needs to get away from. We *need* to get to an SMU model. We need to get a state machine universe.

New: Gravity Transforms *Within* the State Machine

- SMU *requires* relativistic mass to be real and attached to matter
- The gravitational masses of instruments in a spaceship coasting at $0.866 c$ are thus doubled relative to their pre-acceleration masses
- How, then, is Einstein's full inertial-frame symmetry preserved?

Rest Masses M and m at Launch

Masses M and m double in the $0.866 c$ system

25

[50:56] Gravity!

This is just a little intro, real quick, but gravity transforms within the state machine... I just... and now this is something I haven't even got the math... I'll have the math in some later ones here, but if you think about it, everything I've said about these fermions means that if you're using an SMU (using a state machine universe) relativistic mass becomes real, because you no longer have this total relativity between, you know, this frame's absolutely as good as the other. No, they all become subsets and those subsets have enormous energies attached to them.

So if you accelerate a spaceship to near the speed of light, that energy is attached to that spaceship. It's not attached to the space in between, it's not attached to some sub—... it's right there. You have increased the mass of every electron on that spaceship. Now, this presents an interesting question, which... an experiment that no one's been able to do, because we don't have those kind of velocities available to us, or maybe we can be, but if you accelerated an experiment using two masses... This is an old experiment... capital M and lowercase m... you see how much they attract each other.

Well, if you're doing this... and here's the question: If you're doing this in a spaceship that's going at .866C, do you see that extra relativistic mass or don't you? Do those pieces of those balls, do they attract each other faster or don't they? And you go like "Well, okay, you know, if the mass is actually there, *in the observer frame*, in the larger frame I talked about before, absolutely that larger frame is going to have to see those masses attract each other faster. So what's the resolution?

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Distance-to-Time Conversion Rescues Gravity

- Increases in their masses cause moving balls to collide faster
- However, their shared velocity adds length to the interactions
- Conversion of length to time delays the collision in the moving view
- Implication: Gravity transforms *within* Euclidean special relativity

m
 M

M and m collide in a time defined by their masses

$m \times 2$
 $M \times 2$

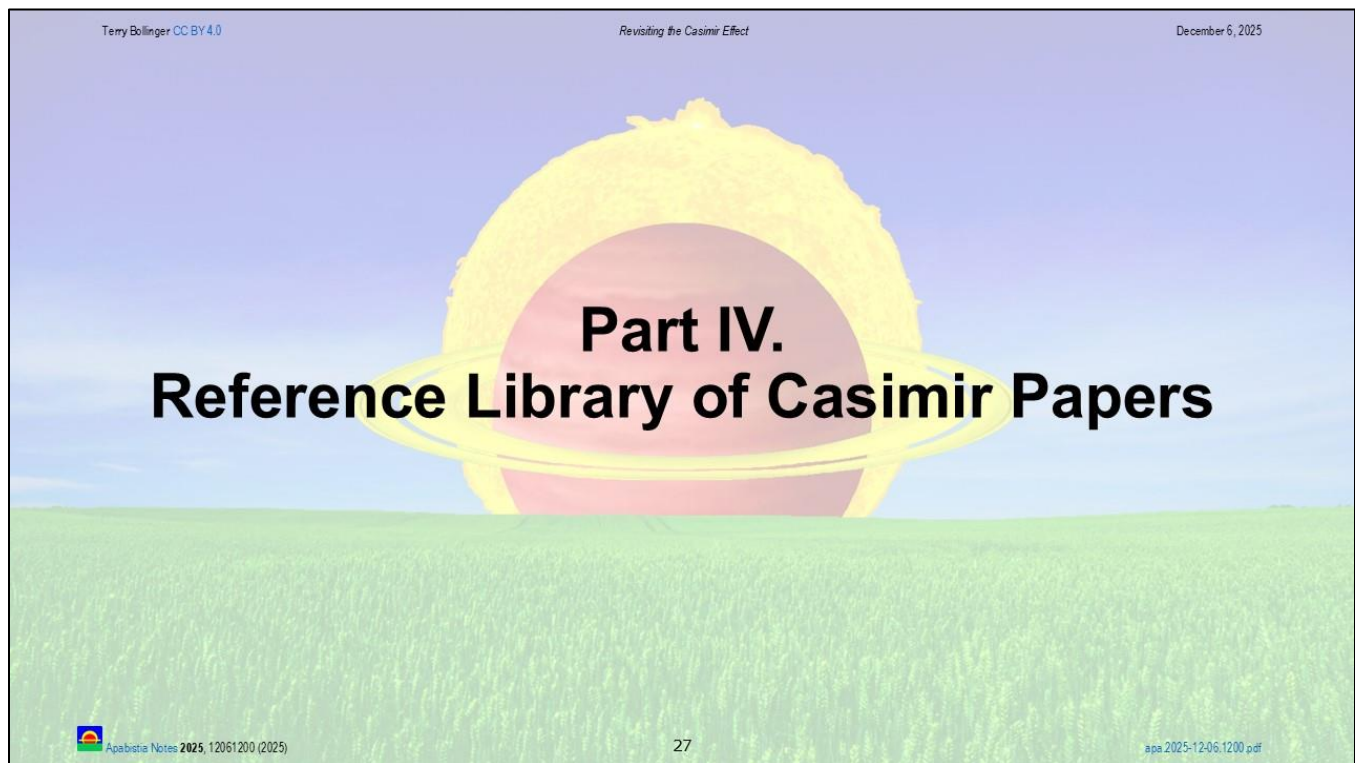
M and m collide faster, but the moving unit sees the added distance as additional time-to-collision

Apabistia Notes 2025, 12061200 (2025)
26
apa.2025-12-06.1200.pdf

[52:41] Well, the resolution is good old space-time interchangeability, because even though the rest frame (the encompassing frame)... I don't like to use the term rest frames, there's no rest—... It's all just scale. When you're talking about a rest frame you're usually talking about the larger inertial frame from which you accelerate it, is what you really mean, and those are multi-scale and they're all an *enormous* number of scales. So what you're really saying is in the encompassing frame in which you observe those masses you *will* see them... you *should* see them (just a prediction)... you *will* see them pulling towards each other faster, but the cool thing is that at the same time they're also moving very fast.

So, from the *internal* perspective of the moving rocket (the ship that has the experiment) *they* see that length converted over into *time* (into an extended time) and they wind up seeing these balls approaching each other at the same slow speed they would have before. So they see no difference in the physics.

Now, think about that though. It means that gravity converts within the Lorentz transformations, which is *intriguing*, because we think gravity is kind of, like, being *larger* than special relativity, but this is the case... as far as I can tell... You know, one of the other things... one of *two* interesting things is going to happen. Either gravity converts within the Lorentz transforms, or it doesn't, and either one of those is an interesting result, because it transforms within those... within there... then you have gravity as, in a sense, in this context, a *subset* of the Lorentz transformations and if it doesn't happen then you have a *violation* of the absolute difference between frames. Either result would be extremely interesting.



[54:31] Oh, *okay*, I'm finally... Now after all that I'm finally getting Casimir, which, again, I've beaten on Casimir multiple times, so I'm just gonna summarize some of this stuff, and go there.

First thing I'm going to do is if you want to look at Casimir... and also just to show I'm not, you know...

A Few Casimir Effect Papers (1 of 5)

- [1] H. Nikolić, *Emergent Diffeomorphism Invariance in Toy Models*, Fortschritte Der Physik 2300026 (2023). <https://arxiv.org/abs/2301.04448>
- [2] A. Albert et al. (HAWC Collaboration), *Constraints on Lorentz invariance violation from HAWC observations of gamma rays above 100 TeV*, Physical Review Letters **124**, 131101 (2020). <https://arxiv.org/abs/1911.08070>
- [3] H. Nikolić, *The Origin of Casimir Effect: Vacuum Energy or van Der Waals Force? [Slides]*, Modern Aspects of Quantum Physics (2018). <http://thphys.irb.hr/wiki/main/images/2/2c/Casimir.pdf>
- [4] H. Nikolić, *Is Zero-Point Energy Physical? A Toy Model for Casimir-like Effect*, Annals of Physics **383**, 181 (2017). <https://arxiv.org/abs/1702.03291>
- [5] H. Nikolić, *Proof That Casimir Force Does Not Originate from Vacuum Energy*, Physics Letters B **761**, 197 (2016). <https://www.sciencedirect.com/science/article/pii/S0370269316304567>
- [6] C. D. Markle, *On the Orientation Dependence of the Casimir Force [PhD Thesis]*, Washington University Open Scholarship, Dec 30, 2013. <https://openscholarship.wustl.edu/etd/1191/>



[54:50] I've done a little bit of reading on this topic. I've done, like, two deep dives on this topic and *never* been satisfied with a full set of results. So, here's a few good ones. These are most recent firsts. There's another set. Here's a few more for you. Oh, and Lamoreaux... I can't pronounce his name, but Steve Lamoreaux... *marvelous* work they did experimentally.

I mean, he's an editor at Academic now, but got some... got a quantum journal there, but that work is just *amazing* work, where they were able to... you know, *tease out* this subtle Casimir force effect, which is a *real* effect. Despite everything I've just been saying, the Casimir force is a real effect. It's just you gotta be careful what you... what you mean by it. So, but a *marvelous* bit of work there and well worth pointing out, and the ancestry of the Casimir Effect is *not* what people think.

They started out with electrical emulsions electrify. You know, all of the *deeper* history of this is very strange, and van der Waals forces, a lot of it's just figuring out how charges like to shuffle around with each other. I've had two previous presentations on this issue... sections of those... and those are listed here, so if you want to take a look at some of that I've... Some of these same slides are in this one though, so I'm just saying that's where I got those from.



A Few Casimir Effect Papers (2 of 5)

- [7] C. D. Markle and R. Cowsik, *General Approach to Casimir Force Problems Based on Local Reflection Amplitudes and Huygens' Principle*, Physical Review A **85**, 052516 (2012).
<https://arxiv.org/abs/1203.5326>
- [8] B. C. Denardo, *Water Wave Analog of the Casimir Effect [Video]*, NPSPHYSICS (YouTube), June 29, 2012. <https://youtu.be/H-GnwnEnLCA>
- [9] B. C. Denardo, J. J. Puda, and A. Larraza, *A Water Wave Analog of the Casimir Effect*, American Journal of Physics **77**, 1095 (2009).
https://wucj.lab.westlake.edu.cn/Others/Casimir_effect.pdf
- [10] Emok, *Casimir Forces on Parallel Plates [Figure]*, Wikipedia (2008).
https://en.wikipedia.org/wiki/Casimir_effect#/media/File:Casimir_plates.svg
- [11] R. L. Jaffe, *The Casimir Effect and the Quantum Vacuum*, Physical Review D **72**, (2005).
<https://arxiv.org/abs/hep-th/0503158>
- [12] S. K. Lamoreaux, *The Casimir Force: Background, Experiments, and Applications*, Reports on Progress in Physics **68**, 201 (2004).
<https://courses.physics.ucsd.edu/2014/Fall/physics215a/project/Casimir-Review.pdf>



[{see slide 28}]

A Few Casimir Effect Papers (3 of 5)

- [13] S. K. Lamoreaux, *Demonstration of the Casimir Force in the 0.6 to 6 Mm Range*, Phys. Rev. Letters **78**, 5 (1997). <http://web.mit.edu/~kardar/www/research/seminars/Casimir/PRL-Lamoreaux.pdf>
- [14] J.-L. Thiffeault, M. Purcell, and R. Correll, *What a Rindler Observer Sees in a Minkowski Vacuum*, PHY 387M, Relativity Theory Course, the University of Texas at Austin (1993).
<https://people.math.wisc.edu/~jeanluc/talks/rindler.pdf>
- [15] J. Schwinger, L. L. DeRaad Jr, and K. A. Milton, *Casimir Effect in Dielectrics*, Annals of Physics **115**, 1 (1978).
<https://www.sciencedirect.com/science/article/abs/pii/0003491678901720>
- [16] T. H. Boyer, *Quantum Electromagnetic Zero-Point Energy of a Conducting Spherical Shell and the Casimir Model for a Charged Particle*, Physical Review **174**, 1764 (1968).
<http://web.mit.edu/~kardar/www/research/seminars/Casimir/PR-Boyer68.pdf>
- [17] E. J. W. Verwey and J. Th. G. Overbeek, *Theory of the Stability of Lyophobic Colloids*, Journal of Colloid Science **10**, 224 (1955).
https://dspace.library.uu.nl/bitstream/handle/1874/16118/verwey_55_theory.pdf



[{see slide 28}]



A Few Casimir Effect Papers (4 of 5)

- [18] J. Th. G. Overbeek and M. J. Sparnaay, *Experiments on Long-Range Attractive Forces between Macroscopic Objects*, Journal of Colloid Science **7**, 343 (1952).
https://dspace.library.uu.nl/bitstream/handle/1874/18537/overbeek_52_experiments.pdf
- [19] E. J. W. Verwey, *Theory of the Electric Double Layer of Stabilized Emulsion*, Proc. Konink. Nederland. Akad. Wetenschap **53**, 375 (1950).
<https://dwc.knaw.nl/DL/publications/PU00018788.pdf>
- [20] H. B. G. Casimir, *On the Attraction between Two Perfectly Conducting Plates*, in Proc. Kon. Ned. Akad. Wet., Vol. 51 (1948), p. 793.
<https://dwc.knaw.nl/DL/publications/PU00018547.pdf>
- [21] H. B. G. Casimir and D. Polder, *The Influence of Retardation on the London-van Der Waals Forces*, Physical Review **73**, 360 (1948).
<https://www.mit.edu/~kardar/research/seminars/Casimir/PR-CasimirPolder48.pdf>
- [22] E. J. W. Verwey and J. Th. G. Overbeek, *Theory of the Stability of Lyophobic Colloids: The Interaction of Sol Particles Having an Electric Double Layer* (Elsevier Publishing Company Inc., 1948). <https://www.damtp.cam.ac.uk/user/gold/pdfs/teaching/VerweyOverbeek.pdf>



[{see slide 28}]

A Few Casimir Effect Papers (5 of 5)

- [23] E. J. W. Verwey, *Theory of the Stability of Lyophobic Colloids [Paper]*, The Journal of Physical Chemistry **51**, 631 (1947). <https://pubs.acs.org/doi/epdf/10.1021/j150453a001>
- [24] H. C. Hamaker, *The London-van Der Waals Attraction between Spherical Particles*, Physica **4**, 1058 (1937). <https://www.damtp.cam.ac.uk/user/gold/pdfs/teaching/hamaker.pdf>

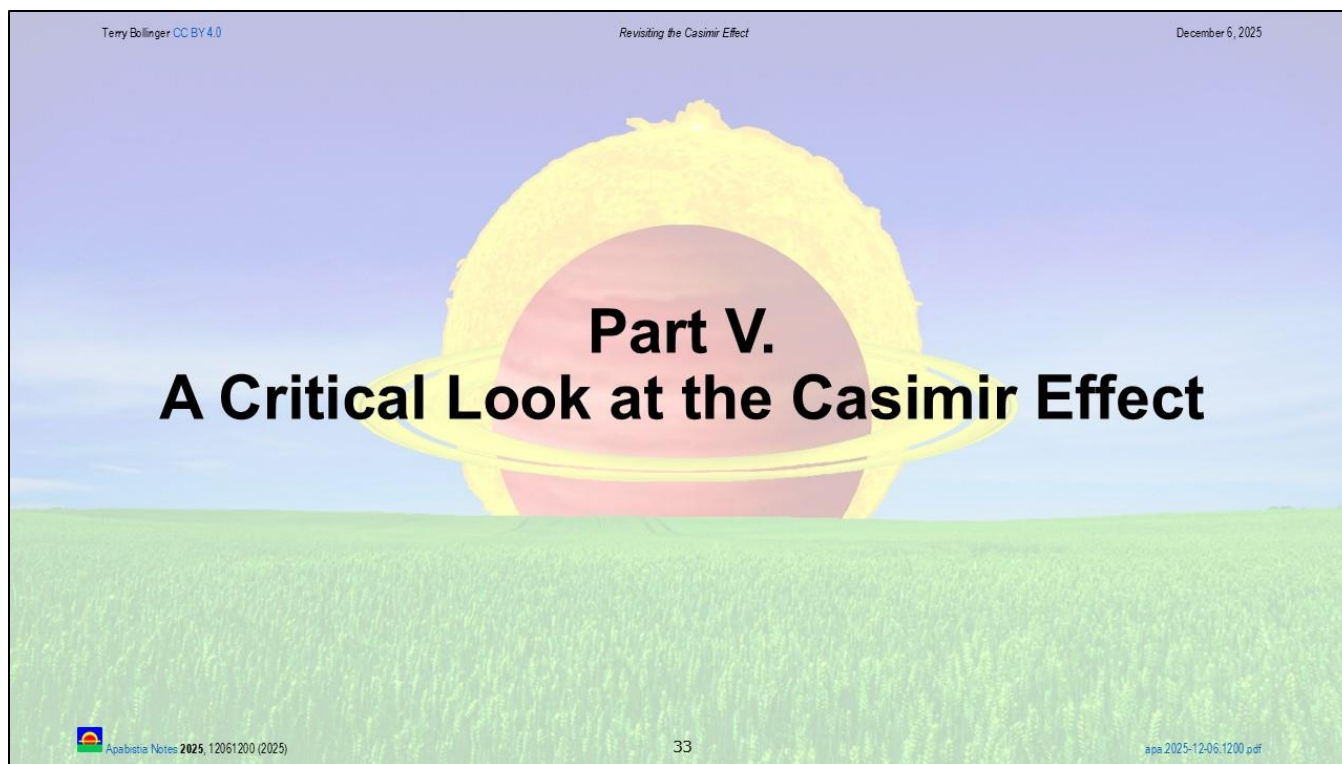
Previous Bollinger YouTube presentations addressing the Casimir Effect:

- [26] T. Bollinger, A Critical Look at Infinitesimals in Physics. Apabistia Notes 2025, 09131200 [Sep. 13] (2025).
Slides: <https://sarxiv.org/apa.2025-09-13.1200.pdf>
Video: <https://youtu.be/4YPvucRP9kw>
This citation: <https://sarxiv.org/apa.2025-09-13.1200.01.pdf>
- [27] T. Bollinger, *Fairy Dust in Physics: How Non-Physical Views of Information Impede Theory Progress*. Apabistia Notes **2025**, 0215130002 [Feb. 15] (2025).
Slides: <https://sarxiv.org/apa.2025-02-15.1300.01.pdf>
Video: https://youtu.be/JjCiI3_7pdg
Edited transcript: <https://sarxiv.org/apa.2025-02-15.1300.02.pdf>
This citation: <https://sarxiv.org/apa.2025-02-15.1300.03.pdf>



[{see slide 28}]





[56:17] Now... Casimir Effect?

Slide 34 has a white background. On the left is a diagram showing two vertical grey rectangular plates. Green wavy lines representing electromagnetic waves are shown between and around the plates. Blue arrows point from the plates towards each other, indicating an attractive force. Labels "Casimir plates" and "Vacuum fluctuations" point to the plates and the waves respectively. Below the diagram is the text: "Emok, CC BY-SA 3.0, via Wikimedia Commons" and a URL: "https://commons.wikimedia.org/wiki/File:Casimir_plates.svg". On the right side of the slide is a quote from H. B. G. Casimir (1948) about the attractive force between two metal plates, followed by a quote from S. K. Lamoreaux (1997) about the experimental confirmation of the effect. At the bottom left is the Apabistia Notes logo and text "Apabistia Notes 2025, 12061200 (2025)". At the bottom center is the number "34". At the bottom right is the text "apa.2025-12-06.1200.pdf".

Standard Casimir: Empty QED Space Has Nearly Infinite Energy

H. B. G. **Casimir**, *On the Attraction between Two Perfectly Conducting Plates*, Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen 51, 793–795 (1948).
<https://dwc.knaw.nl/DL/publications/PU00018547.pdf>

"We are thus led to the following conclusions. *There exists an attractive force between two metal plates which is independent of the material of the plates as long as the distance is so large that for wavelengths comparable with that distance the penetration depth is small compared with the distance. This force may be interpreted as a zero-point pressure of electromagnetic waves.*"

"Although the effect is small, *an experimental confirmation seems not unfeasible and might be of a certain interest.*"

Forty-nine years later, **S. K. Lamoreaux** proved that the attractive effect Casimir predicted is experimentally observable:

S. K. Lamoreaux, *Demonstration of the Casimir Force in the 0.6 to 6 μm Range*, Physical Review Letters 78, 5–8 (1997).
<http://web.mit.edu/~kardar/www/research/seminars/Casimir/PRL-Lamoreaux.pdf>

[56:20] ... itself. Standard Casimir:

Empty space has *nearly* infinite energy. This is what Feynman *complained* about about his own theory. He said, “Wow, this doesn’t seem quite right.”. It’s hard to balance it out. People have struggled. The simplest prediction is that if you *truly* have *infinite* forces due to quantum uncertainty at small enough scales that you should have *infinite* density of the... either infinite *negative* density or infinite *positive* density of empty space and the whole universe collapses, and the balancing point between those two is *so unbelievably thin*.

I remember I did a calculation once. You take the universe. You look at a proton, then you make that proton into your universe and then you take another proton and you make that proton into your universe and I think it was like I don’t know... three or four times, and then you finally get *how* sharp of an edge you need to keep the vacuum from collapsing due to this. So, it’s... When I say there’s a problem with the quantum field theory on this I’m not kidding. It *really* goes crazy on trying to go to the finest levels of detail. So, you have this attractive force and the idea is that if you have these plates it restricts them from bumping into each other.

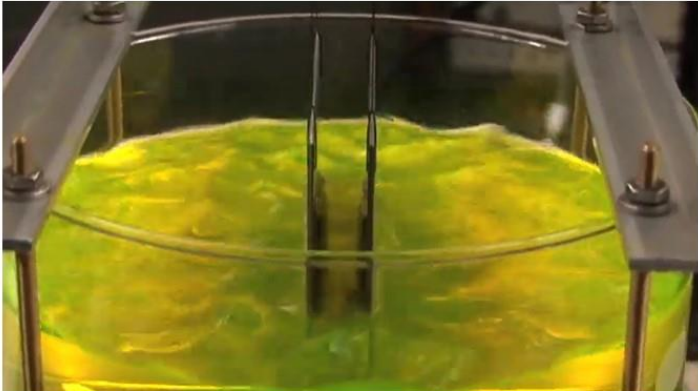
If you’ve ever been on a boat next to a dock and you put your hand in between the dock and the boat you can get your fingers crushed, because of the Casimir effect or the equivalent up in the waves. The waves will push the boat into that shadow created by the waves. These are just shadows. That’s all these really are. That distance between those plates is a shadow. So the waves outside push them together. So, this is where you get the idea of attractive force, but *notice* the attractive force is *not* from the gap. That’s misinterpreting it. That’s just a shadow. The pushing force is from the *outside*. It’s from all the forces on the *outside* of the plates trying to crush the plates together.

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

All Real Casimir Models Require Violent Waves

2:30 “*This is tricky because we are pushing the shaker and the amplifier nearly to their limits.*”

— B. C. Denardo, *Water Wave Analog of the Casimir Effect*. NPSPHYSICS (YouTube), [Jun. 29] (2012). <https://youtu.be/H-GnwnEnLCA>



 Apabistia Notes 2025, 12061200 (2025)
35
apa.2025-12-06.1200.pdf

[58:25] ... and *that’s* a bit of a problem *because* if you do a real Casimir model... It’s a great little video where they show this effect... If you *crank up* the shaker on a beaker and you have two plates there you will observe the equivalent (the aquatic equivalent) of the Casimir effect, and in order to do it... I like the way the guy (the fellow) says this... Dr. Denardo... but the way he says this [is] “This is tricky, because you push it *near* the limits before you can finally get this thing to take effect.”. You really have to get those waves moving. That corresponds to the nearly *infinite* frequencies that you have at the lower scale of these things. So, it’s a *violent* thing...

Terry Bollinger CC BY 4.0

Revisiting the Casimir Effect

December 6, 2025

Absurdity #1: Casimir Effect Creates Black Holes

- What folks tend to forget about Casimir plates is that **the force comes entirely from *outside* the plates, not from the gap**
- The gap is nothing more than a region where **a tiny sliver of all possible “free space” oscillations cannot exist**
- This absence then makes *a sliver* of the outside wave forces visible
- There is a huge problem with this argument:
 - The ultimate “thin gap” is the ***solid metal within each plate*** (zero gap)
 - Applying the gap rule consistently means the gamma-and-beyond **quantum fluctuations should crush each plate until it becomes a black hole**
 - The gap model works *only* if you “exempt” all but a minute sliver of waves



Apabistia Notes 2025, 12061200 (2025)

36

apa.2025-12-06.1200.pdf

[59:05] ... and *this* creates an absurdity. There's no other way to describe it. If the Casimir effect was *real* and as described every metal block would turn into a black hole. Why? Because every metal block would have infinite forces pushing inward on it due to that block not permitting the full range of *forces* to cancel out. So it's like a... like that submarine that's at the bottom of the ocean, you know, and it gets crushed because it's got a hole, it's got a gap on the inside, and if that's not filled in it can't resist those forces.

So, this creates a concept that any metal plate... because, if you think about it, a metal plate has *no gap at all*. It's a *zero* gap, so that means that all the forces should come in full play. So, the only way you make the Casimir effect work is if you *exempt* all but an *incredibly* tiny sliver of the waves, and... which is exactly what has happened, because you say, like “Well, if *these* waves don't work, and *these* waves don't work, and *these* waves don't work, but *this little tiny sliver*, this little tiny sliver, this little tiny sliver of waves... They do that. Then you get the measured effects and you can actually calculate out within that tiny little narrow strip, but then you gotta, you know, you gotta look at it a little closer and say “How are you doing this exemption?”.



Absurdity #2: Casimir Effect Incinerates All Matter

- Casimir's explanation for exempting most forms of radiation:

"For very short waves (X-rays, e.g.) our plate is hardly an obstacle at all."

— H. B. G. Casimir, *On the Attraction between Two Perfectly Conducting Plates*, Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen 51, 793–795 (1948).

<https://dwc.knaw.nl/DL/publications/PU00018547.pdf>

- There exists **no physics pathway** by which Casimir's assertion of **"transparency"** is plausible
- Far from being transparent to them, **metal plates should absorb or reflect X-rays and higher energies**
- The only correct outcome of this thought problem scenario is **cosmic incineration of all matter** (if black holes do not form first)



[1:00:30] And, this was one of the (to me) one of the funniest statements that I recall reading [in] a paper, because I just rolled my eyes and laughed. I said "You've got to be kidding!", because Casimir said originally, for very short waves, like X-rays, EG... you might have included gamma rays, extreme gamma rays, and all those other rays that go beyond that... our plate is hardly an obstacle at all. *What?! What??* If... Let me... Here's a question for you: If you take some metal object that you have and put it into a gamma-ray machine and *see if nothing happens to it*, or put it in an X-ray machine and *see if nothing happens to it*. This is *absurd!* The trans—... the assertion... First of all, the assertion of transparency is *not* correct, and it also ignores all the *consequences* of those *higher* frequency waves.

So, it's a [specious] argument to say the least, but also just *funny*. It's just kind of like, *seriously?! That's your way of saying that that's why it's so weak?* It's you just say "Nope, nope. All those highways, they just go right in through it." So, the other consequence of that is cosmic incineration. (Actually, I think I went through here.)

... creates... first of all, it creates black holes. I skipped over that... Cosmic incineration... because the *energy* is going to *obliterate* the matter in that. This model doesn't work! It requires space to be *so energetic* that a material object that is in *any* way an impediment to that (which is pretty much *any* kind of matter... some degree of impediment) should be *incinerated*.



A Belated Clarification (Confession?): Casimir 1998

Near the end of his life in 2000, Casimir said this:

“But one can also take a more modest point of view.

Inside a metal, there are forces of cohesion. And if you take two metal plates and press them together, these forces of cohesion begin to act. On the other hand, you can start from one piece and split it. Then you have first to break chemical bonds and next to overcome van der Waals forces of classical type. And if you separate the two pieces even further, there remains a curious little tail.

The Casimir force is the last but also the most elegant trace of cohesion energy.”

— H. B. G. Casimir, *Some Remarks on the History of the So Called Casimir Effect*, pp. 3–9 in M. Bordag, Ed., Leipzig, *The Casimir Effect 50 Years Later: The Proceedings of the Fourth Workshop on Quantum Field Theory Under the Influence of External Conditions*, Germany: World Scientific, [Sep. 14–18] (1998). See end of page 7: <https://books.google.com/books?id=PI84DwAAQBAJ&pg=PA7>



[1:02:11] So, one of the most interesting statements from Casimir is... much later, a couple years before his before his passing is... I was surprised to see this, because this is something I had been working on independently of ever finding this quote.

It was exactly this kind of thing, as you'll see some in pictures, and it just says the Casimir force is the last but also most elegant trace of *cohesion energy*. I have an assertion. I say that that's the real Casimir talking. *All* the other stuff where it says, like “Yeah, maybe, yeah...”. I think he didn't believe his own excuse. I believe that he may have meant it when he wrote that paper, but after he thought about it he said that doesn't make any sense. You can't just say the x-rays are there and it just ignores them. That makes no sense, because everything would be *obliterated*. Every atom would be obliterated. All forms of matter would be obliterated, so I think Casimir figured that out pretty quickly, but he was *stuck*.

You know, Niels Bohr had supported him. Niels Bohr was *delighted* with his result. He thought it thoroughly proved his model that there's infinite energy at small scales. I don't think Casimir ever truly believed it. I think he was *very cautious* and it's interesting how he didn't even like his name to be associated with this. These are the kind of things that people do when they don't really fully agree with the discussion that's been assigned to them and I think that's the case for Casimir. So, *fascinating* quote by Casimir and also an important quote because...

Relevance of SMU to the Casimir Effect

- The **State Machine Universe (SMU) excludes every major aspect of Niels Bohr's interpretation of the Casimir effect**
- The very *concept* of a **spacetime fabric disappears (operators only)**
- **All versions of "infinite" energy at very short distances disappear**
- All particles in the Standard Model become *emergences*, funded solely by how much energy is locally available
 - Particle *emergences* reveal *rules* guiding specialized state transformations
 - Particles represent specific "recipes" for funding and creating novel, extremely **localized variations of higher-complexity spacetime**
 - **Protons, for example, are extremely stable local spacetime states** with only the *potential* to generate quarks, gluons, pions, and other phenomena

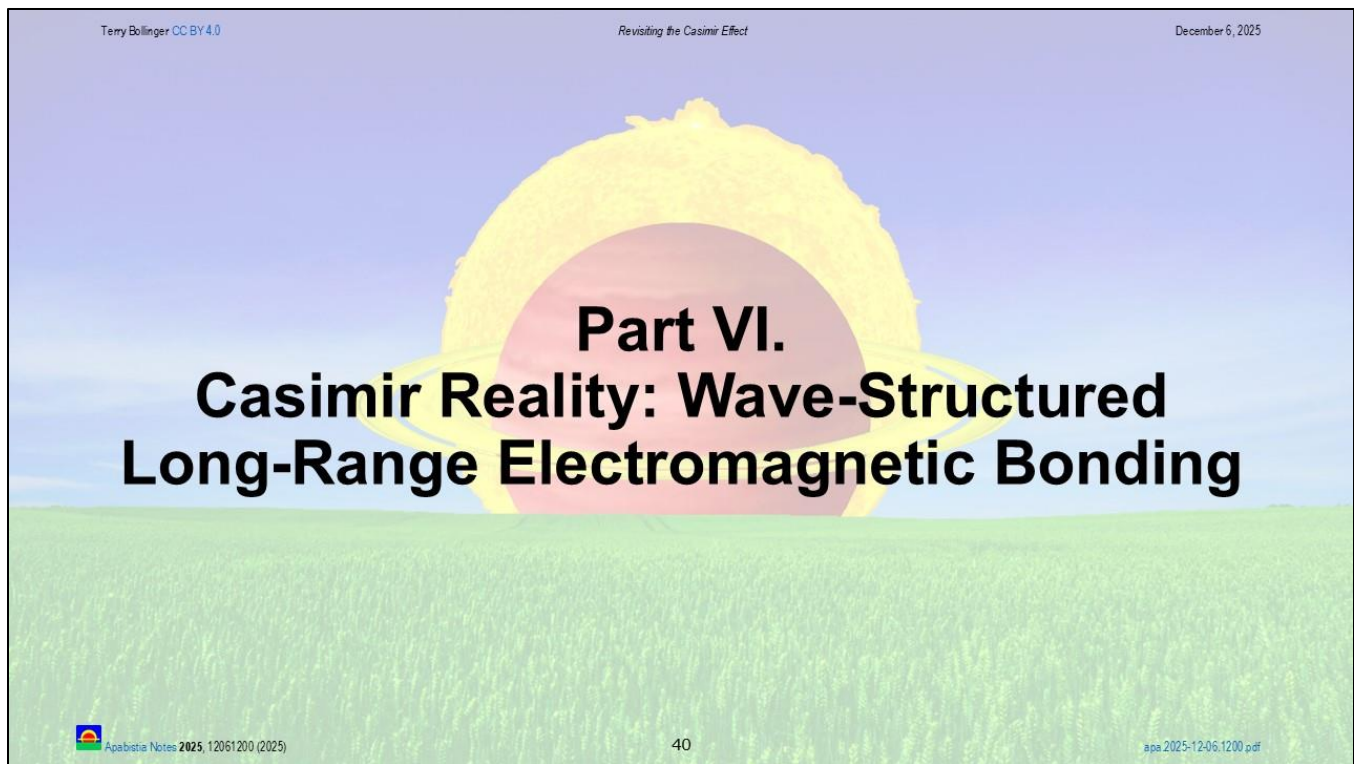


[\[1:03:53\]](#) ... It leads you to... Well, it's important because it leads you some explanations that make more sense. In terms of the SMU (State Machine Model)... State machine universe excludes every aspect of Niels Bohr's interpretation of the Casimir effect. There's no space-time fabric. There's operators only. There's no infinite energies at short distances. That's just a [specious] concept. *Species?* I'm not even sure if I pronounced that word right. Specious concept... and more interestingly though is if you *abandon* this idea that there's a very well-structured four-dimensional space-time as a *given*, then all of the particles that you see in standard models become emergences of some form of matter defining some combination of spatial and time characteristics. This is a complete upside-down version of how we usually think of it. Think of it as matter, of persistent matter, fermionic matter, fermionic matter and energy combined... funding the development of interesting configurations of space-time, because space-time becomes a much more fungible asset in this model, because it's just operators.

So you use small-scale operators that don't quite create a full definition of space-time. Half-spin would be an example. That's not a full definition of space-time. Half-spin is a *partial* definition of space-time. It's a very *weird* partial definition of space-time. You have rules that... The particle emergences reveal the rules for guidance, but they don't mean that those are all in operation at the same time. As an example, that proton would be extremely stable. Local space-time states... They don't have energy beyond what they're funded with, and they only show things like quarks, gluons, [and] pions when they interact with various levels of energy with phenomena that say "Oh, okay. I can *do* that now. I can spit that out.". It's... In some ways it's subtle, but it's an important distinction to make, that the idea that you have stable states that allow the *emergence* of complexity without actually having the complexity.

The electron orbital is *not* a superposition of an infinite number of electrons doing a little bit of everything all at the same time. It is simply a set of rules that say "I'm here. This is as compact I can get under this set of informa—... this set of mass and energy. Can't do anything more, but here's what I'm capable of, if you ask me. Here's what I could do if you do that.". So a state machine model gives a more precise way of saying that: "What is your next state that is possible if you do that?".





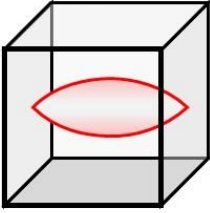
[\[1:06:42\]](#) Casimir Reality...

If [the] Casimir effect doesn't exist. If there's no way that you can wing it around so that you can get these infinite electromagnetic waves, then *why* has it been detected? Because that work that was done *absolutely* showed the existence of a *small* (very small)... After you factor out van der Waals forces, which is a *really* interesting story all by itself. After you factor out the van der Waals and if you factor out other things that we can explain more conventionally, you still have a lingering little bit of *attraction*, and that is the attraction that follows a wave-like model. Well, why would that be?

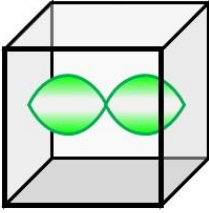
Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Wave-Like Electrons and Long-Range Bonding

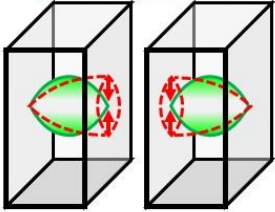
Conduction electrons are waves, not particles



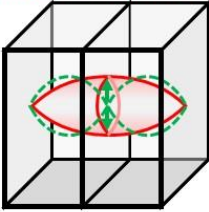
You must add energy to add more loops



Pulling two plates apart locks in this added energy



Casimir Effect: Stored energy gently pull plates back together



- The “interesting” properties of metals stem mostly from electrons behaving like waves
 - Conduction
 - Reflection
 - Ductile strength
- Breaking a piece of metal also breaks some of these bonds
- Casimire (1998) noted that it is this bond breaking that creates the effect named for him (!)

 Apabistia Notes 2025, 12061200 (2025)
41
apa.2025-12-06.1200.pdf

[1:07:31] One of the things I want to point out is when you’re talking about metals you are talking about substances that have electrons that exist as *waves*.

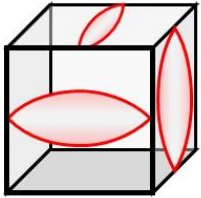
The idea that electrons are purely little particles just doesn’t work for metals. You *have* to use the wave model for electrons, and this is just a simple example. You’ve got a block of metal. You have electron states. This is standard conduction theory (standard band theory) from metals and from semiconductors. So, you have these different wave states, then you have like one loop of a skip rope, you have two loops, you have three loops. It keeps increasing.

If you break that block apart you are also forcing the lower energy states to break into higher energy states. In other words, this is why metal is strong. This is... Why? Because it doesn’t want to do that. You require some energy in order to break that. Well, the fact that you put energy *into* it means you can get energy *out* of it, and this is your true source of the Casimir effect. It’s saying that (just as Casimir said in his later years)... you know, it’s the last little bit, that if you break the pieces apart the bonding’s going to try to pull them back together. You can release that energy that you created by putting those pieces closer together. Well, how does that work out in detail?

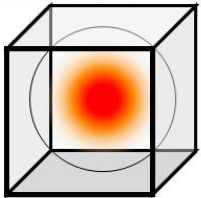
Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

How Do Electron Waves Create Long-Range Bonds?

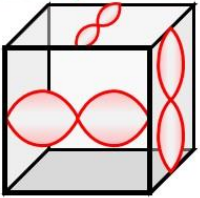
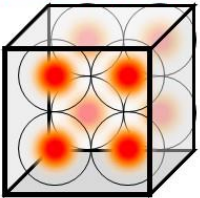
Electrons form waves in all three directions



Result: Weak, multi-scale concentrations of charge



More energetic electron waves also go all three ways

- The lowest-energy electrons create human-scale “lumps” (polarons) in charge distributions
- While tiny, even one non-even electron has substantial charge
 - These distributions mimic the situation that gives van der Waals
 - The scale is vastly larger, however
- Most of the attraction arises from the lowest-energy electrons
- Most electrons add very little

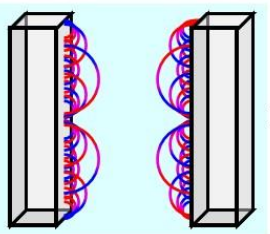
Apabistia Notes 2025, 12061200 (2025)
42
apa.2025-12-06.1200.pdf

[1:08:53] Well, one of the *other* things you want to see is that there's interesting structuring even in a block of metal, and that metal structure and that structuring of charge is very low level. It's very small. It involves in some cases just individual pairs of electrons, but it's *still* there, and what happens is electrons in the base state form the lower left-hand model you see, where you've got just a single concentration of charge towards the center of the block, but you also have more complicated ones where you have like all four, all eight of these things... will form in that cube. So these are *non-even* charge distributions that form naturally as a result of the wave-like behavior of the block, of steel, of any kind of metal, especially silver. Silver's always great.

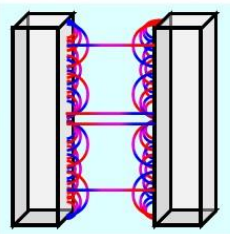
Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Frequency Dependence of the Casimir Effect

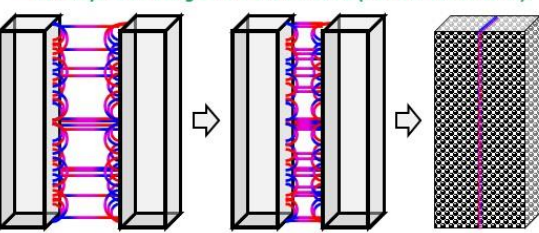
(a) Too far for the Casimir Effect!



(b) Largest polarons link first



(c) Reducing gap links smaller-scale polarons and increases pull. Pull stops increasing at the atomic scale (van der Waals limit).



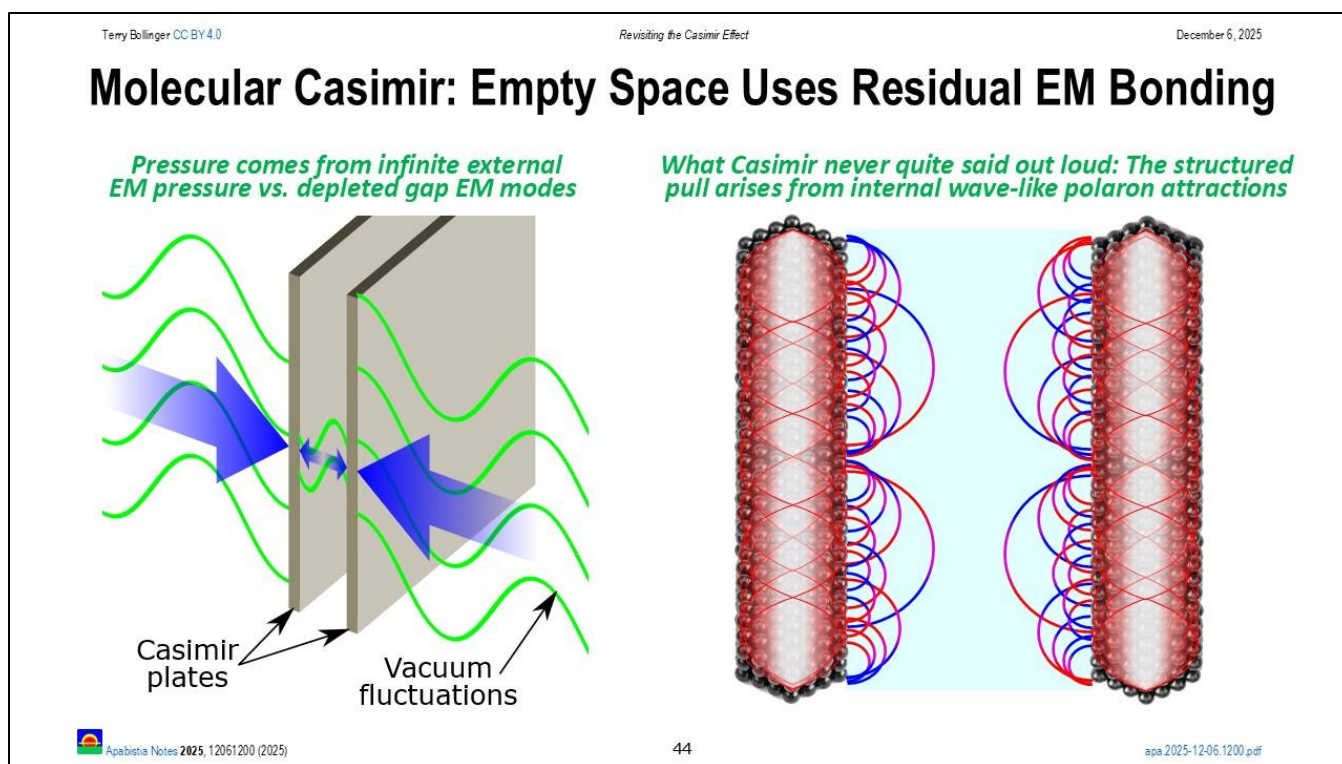
- The Casimir attraction depends directly on resonant electron wave polaron charge distributions
- Consequently:
 - The lowest frequencies contribute most to the attraction effect
 - The highest frequencies add little
 - There is always an atomic cut-off
- These effects are detectable at laboratory scales
- Larger gaps help suppress van der Waals contributions

Apabistia Notes 2025, 12061200 (2025)
43
apa.2025-12-06.1200.pdf

[1:09:43] Well, what does *that* do? It means that if you have these charge distributions they form fields that extend out from the metal, and the way that this is... the fact that you have this extension of the metal... You get different degrees of attraction based on the separation of the different charges.

Now, this is something and this is one... One of the reasons I did these deep dives is I wanted to work out the math of this in full detail. So, I have *not* done that, so I'm leaving it at this higher level, but *this* part of it is quite solid, that there's going to be field distributions that have a wave-like character to them, and that wave-like character *should* produce a contribution beyond the van der Waals forces that looks like it was produced by waves, but it is *not* the same thing as the frequencies of the outside quantum field theory. It is instead that last lingering attraction that Casimir talked about.

This is what he was *talking* about, and the... and I wouldn't... I don't know if he ever analyzed this in more detail to get to the point of saying, like "Oh, that's what's going on.", but he *might* have. I don't know, and it would be fascinating to find out if he ever actually published anything else that went into more detail. I doubt that he did, because again this was a very touchy topic for Casimir because he was in a bit of a bind, but he clearly thought something much more like this was going on.



[1:11:18] You can see those... Again, instead of on the left you want to look on the right. So what you have is you have these loops of just different charge distributions that have come into play at different levels. They're a result of the inherently wave-like nature of conduction electrons and they're going to mimic and give results that look a lot like frequency occlusions. So, again, marvelous paper... and this is... People have encouraged me to do a paper on this. My apologies, I've not gotten around to doing it, but I, you know, anybody who wants to take a go at it, I put the references out there to help on doing this analysis.

Terry Bollinger CC BY 4.0
Revisiting the Casimir Effect
December 6, 2025

Summary

- Minkowski space is a math error that must be deprecated
- Treating reality as a state machine simplifies special relativity and allows a fully Euclidean treatment of space and time. (Note: There is a high potential for quaternions to “click” better with this model.)
- The role of information needs serious upgrading, e.g., to explain quantum mechanics more as a low-resolution phenomenon
- Something is seriously, seriously incorrect in the foundations of quantum field theory (but *not* most of the results)
- Bohr’s interpretation of Casimir’s long-distance bonding resulted in astonishing levels of mathematical misdirection

 Apabistia Notes 2025, 12061200 (2025)
45
apa.2025-12-06.1200.pdf

[\[1:11:58\]](#) With that we’ll wrap this up, and of course my emphasis, again, is... I’ve already beaten Casimir to death. It’s the third time I’ve beaten on Casimir. So, I’m gonna beat on a different topic. Minkowski space is a math error. It *must* be deprecated. It needs to be abandoned, and how’s that for blunt? But, I don’t see any way around it, and it *wasn’t* Minkowski’s *fault*. This was a subtle error that came in *to* him *from* Einstein, who *also* did not notice that there was a very subtle error in a simple assumption he made in one line of one paper in 1907, but then followed up on it and kept that as essentially a bug in the math. Computer science viewpoint: This is an interesting issue about bugs. You get one bug deep in your math and *wow*... in your code... and all sorts of interesting things can be a consequence.

So, we need to go with something *much more* like the tilted block model in which everything starts from the same state. You’re simply tilting the states. You’re changing the things. It is a *physical* operation. *Nothing* goes into the past. You’re creating new definition of space and time, but it’s not magic. It’s localized, and you *always* have a full Euclidean definition, just as CERN does for its relativistic particles, in which you embed the results *fully* in the larger LAB definition of space-time. LAB being a bit of a pun there. The latest... It’s the latest bubble, but it’s also just [a LAB]. ([As you may have noticed], there’s an intentional acronym collision there!)

We need to recognize the role of information and the finite nature of information *much more* precisely to get better explanations of some of what’s going on in quantum mechanics, and I... If we understand the information more, we can understand better the parts that *don’t* match up with our usual definitions of finite limits in space-time, because these things are interacting in some fashion that defies our usual definitions of finite time.

Information is the quantity that places us into a finite universe and makes this state machine possible. We have an interesting paradox here. The very *limits* that information imposes are what make our universe possible and make it possible for us to talk about this stuff. So, you know, it’s like *wow*, that’s an interesting conundrum. So how... What *can* you do and how much can you do it if you get below that level to the physics where all of these things are talking to each other to some degree, in some fashion that we don’t understand?

Quantum field theory... The idea that intergalactic space is full of an ether... which is what quantum field theory really does. It just... It recreates an ether and we can pretend it doesn’t all we want, but it recreates an ether. We

gotta get rid of that ether, but that throws us into a *very* different world in which interactions *don't* follow the limits we would expect.

You know, somehow a photon gets emitted at a different distance star. It doesn't really exactly *cross* the empty space in between, but it does have a finite amount of time before it's allowed to interact with a *whole* bunch of things that are on the periphery of that, and just... The idea of going to an SMU (to a state machine universe) allows us to explore things like that I think in a *very* different way.

So we stopped using this idea of... We *gotta* get away from the ether, and again, *this* is the problem with quantum field theory. *It is an ether theory!* Just *look* at it! It fills space with little devices that vibrate. That's an ether! So, we need to get away from that. It may put us in weird turf, but we need to get out.

Oh... Casimir's... The interpretation of the Casimir effect was a *proof* of infinite energy at small distances was a *terrible* misdirection of a lot of effort, because... Yeah, first of all it just experimentally... Casimir said it before I ever said it... long before I ever said it... It's that, no, it's just *bonding* energy. That's all! It's structured in a way that looks like waves. Fine, but it's just *bonding* energy. It's not an insight. It doesn't prove... If anything it proves that there *is* finite energy. It says that "No, that's all you get, is this tiny, tiny little pittance of energy that was stored when you broke the blocks apart.". So, that should not be made the foundation of decades, even a century, of mathematical analysis. We *need* to get away from that and to *stop* making infinities at these low levels and get to something more like a state machine model, and with that I am finished.



Questions and Answers from after the presentation:

TX = Team OrionX (Helen Ma)

TB = Terry Bollinger

RB = Robert E. Becker

CP = Caetano Peng

WS = William Slater

RS = Ron Schreiner

...

[1:17:20] TX: Thank you for the talk. I noticed Robert Baker; he has four questions.

Can you unmute and ask yourself?

TB: Yes, let me get the... I gotta get the... uh, “stop share”... There we go!

TX: Yes, there you go. Yes. Yeah, can you ask the floor questions online?

RB: Yes, I can... Well, I did put the four questions... and I can ask them verbally if you want, whatever is easier. I didn't want to interrupt and I don't—

TB: How about, how about verbally?

RB: Okay, I don't seem to have one of those hand-raised flags on my setup here, so I had to put it in the chat. Okay, I guess—

TB: I think it's under “react”, under “reactors”.

RB: I can't hear you.

TB: I think it's under “react”.

RB: Oh, it's under rea—... Oh, that's what that is? Oh, okay. Thank you. I'm not used to using Zoom. I'm used to using Teams and things like that.

[1:18:18] All right. First one was, you mentioned in one of the earlier slides that the fermionic universe, I think, is the state machine universe and so it occurred to me if that is true then what is the bosonic universe?

TB: The bosonic—

RB: We know bosons exist. They're bosons. We believe gravitons exist. There's even an experiment proposed to detect single gravitons. We believe from particle physics (experimental particle physics) that intermediate vector bosons exist. So, is there a difference between a fermionic universe and a bosonic universe in your conception?

[1:18:54] TB: The reason I emphasize fermionic is that without the fermionic half-spin property of exclusion you can't construct a full system that encodes information in a... You get this scale-free universe where it's very difficult to define a *persistent* definition of information. Now, if you have some fermionic content, at least a little tiny bit of fermionic content, then you have this ability to configure the bosonic components into all sorts of information.



We do that all the time. We broadcast on radio waves. We send *enormous* amounts of information using light over fiber optic cables, but what you want to notice is that in order to *enable* those it *seems* to be the case that we have to have at least a little smidge of this fermionic property to *do* that. So all the things you mentioned about, you know, that you have gravitons... These are... I haven't seen the part about the gravitons, but gravitational experiments where you get particles... at some point, we should get some quantization of gravitational forces. So, yeah, that stays the same. It just says that—

[1:20:04] RB: In my own work from decades and decades ago I had proposed gravito-magnetic flux quantization, but these modern experiments, more recently, they actually *are* looking for single gravitons. They're trying to do a single graviton detection similar to single photon optics. So, that's why I had mentioned that, but that's an interesting point you raised there about the information. So, basically, you're not excluding bosons, you're not saying that bosons are incompatible with your SMU model—

TB: Oh, no. Not at all.

RB: ... simply—

RB: ... more than that to have an information content you would need to have fermionic content—

TB: Right.

[1:20:45] RB: ... [fermionic content added] to it. Alright, that's an interesting point. Okay. Okay, next one was... Yeah, I... In the DAU, what I've looked for in work like the... in kind of very innovative, work like this is I try to (and there's no insult to the author, of course) but I try to see are there any tautologies in there? In other words, is there any assumptions being made which are actually being that which is either being asserted or proven by the model.

So in this case here we're basically saying that space and time, even as concepts at all is emergent from the state machine conception, the state machine operations activity, as illustrated in your DAU diagrams. So, what I notice on the bottom, of course, there's an axis where you have these arrows. Even in the rest case scenario you have these arrows (vertical arrows) in... staged right, you know, next to each other, marching across the bottom axis, which you call distance, and so my question was what actually *are* each of those arrows? Are they associated with... You can't say they're associated with a point in space, because in your conception that does not exist, or at least does not exist primordially. Are they associated with a piece of matter?—

TB: Yes.

[1:22:11] RB: Are they associated with a... So, you're saying these are little pieces of matter that are arrayed *non-overlapping*. We could use topological terminology. You're probably familiar with T0, T1, T2, T3 topologies (separation topologies). You could probably define that topologically. It might be a good idea to do so to make it mathematically precise, but... so those are little pieces of matters. They could be... Would they?... Do the?... Must they be all the same scale? Can one have a particle next to a rocket ship, next to a galaxy, next to a particle, or what is the... how are those things staged? Are we assuming that there's kind of an equivalence class of items that constitute let's [say] that array of arrows?

[1:23:04] TB: The scale can be multiple scales and can include different sized units of matter. When I showed the picture of the CERN facility tracking individual particles, that's an example of two different size scales of matter units operating under the same DAU. So you have the... you have a finite amount of time that passes in the CERN facility and you have a finite amount of time that you place in the operation of that particular particle.

Now, usually you're going to want to break it down to a smaller level for the particle, but you *can* do that. You can take... You don't... The units do not have to be the same size. You *do* need to have the same definition of... of the embedding frame time. It defines the length of your unit. So you pick a quantity for your largest embedding frame (your LAB frame). You say: I'm going to use an hour. I'm going to use a nanosecond. I'm going to use whatever unit of time you want, and that defines the length of the operator that then applies to all units within that system, and the assumption is, and again, it *is* an assumption, but it's one that tracks very well with the actual behavior we see, is that you have this inevitable velocity that you can either loop or extend in one direction, and then that is the angle of the DAU unit for this.

So, multiple scales, again, it's just a matter of what you can find as a unit that makes sense for the context that you're doing. If you're doing a large laboratory, you want to have one large DAU unit. For the laboratory you might have it over a short distance. [There are a] number of ways you can configure it. So—

[1:24:40] RB: Okay, that raised an interesting... So in a certain case, the multi-scale is you have the particles being measured or tracked on the one hand, then you've got the gigantic experimental apparatus on the other hand as part of that. That's the... Would that be roughly the multi-scale you're talking about there?

[1:24:58] TB: Yeah, there's... In that case you're probably going to want to be using laboratory-scale DAU units. You're saying... You're making the increment size something that's appropriate for the laboratory, but then you're tracking a *much, much* smaller unit of matter within that, and watching how it behaves with that. So you wind up with pretty much what you see in those kinds of tracks. You see these... the increments forming, the different locations, the different isolations of the particle in the bubble chamber. Those become the little increments of whatever DAU unit that you're using, because you want to have a fairly small DAU unit for the laboratory as a whole.

The concept that really kind of *drives* it is just keeping this idea that you'd never lose the time and space definition of the embedding laboratory coordinates. They're still there, and again CERN is just a beautiful example of that, that these particles are behaving in all sorts of relativistic ways, but it doesn't really matter. You can see it. When we use spaceship examples I think we're too prone to thinking that the spaceship can just whiz by and we pretend that we can't see it. That's just... That's not a good model.

Einstein himself *derived* the time dilation effect by making sure you tracked and you touched every piece of that... whatever the object was as it moved by. That's how he figured it out. That's how he figured out that time dilation was real. So, we can always instrument at different levels and this is just... The state machine just gives a convenient way of saying that that instantly puts limits on the fact that you have to attach every DAU to a material. When I say material I mean mass and energy. It's fine if it... again, a little smidge of fermionic matter goes a long way. You can have a *lot* of energy associated with it, but you have to have some kind of... The fermionic matter is the one that *most* defines the idea of a definition of time. It says that this is where I want to go if I'm just sitting there at rest.

[1:27:07] RB: It was... Well, speaking of time, is there... you mentioned loops. In terms of time for basically rest (stationary) is there a concept in your concept akin to what differential geometry for general relativity for example would be called a CTC, a closed time-like curve. Are there such loops within *your* SMU conception?—

[1:27:37] TB: At this point, I have tried to avoid the curvature of space issue, because unavoidably it says that curvature of space has to be a set of relationship between mass-energy systems. So it does... just as it did for the other parts... it says that these are relationships, but the curvature is a fascinating issue and you're going to emerge... It doesn't... You don't get rid of curvature concepts, but you do transform the attachment of those concepts to matter itself. So it... The state machine model *unavoidably* says that even on a black hole that that black hole still has to remain attached to fermionic matter, and I've addressed this in some early presentations, but even though the overt behavior...

A black hole, is exactly what's predicted by general relativity. We've seen that experimentally, although with some catches, you know, some of the things that some... things that we thought fell into the black hole haven't fallen into it yet... is a noticeable example experimentally, but that says that the matter of that black hole still exists in some fashion and is on the event horizon surface. So the overt characteristics from a distance of the black hole look the same, but the actual dynamics inside would be *very, very* different, and that's an example of where that would affect the curvature issues. You don't wind up with singularities at the center of a black hole. So, a lot of interesting issues, and again, that's...

[1:29:18] RB: Okay. Let's see, next (last of two), you actually raised it a moment ago, the relationship between the SMU and matter-energy... as I understand it the SMU is a sub—... what I would call a substratum concept relative to what we think of [as] classical physics or even quantum physics (matter-energy), yet at the same time, it's ineluctably tied *to* matter-energy. So, which concept comes first? To put it another way, is matter-energy emerging from the state machine or vice versa? How does matter store the state machine as you say? I think that's actually your term from earlier in the lecture. How does matter store the state machine and which is emergent from the other or are they both co-emergent?

[1:30:22] TB: Co-emergent is the term I would use for it, because the properties of matter on how matter interacts with itself, are *powerfully* a part of how this works. Now, in quantum physics, if you're familiar with the idea of decoherence... I like the idea of decoherence up to a point, but I think it's overly complicated. My own way of saying decoherence is bumping, that whenever you bump an object you actually collapse what we would think of as a wave function. So, the bumping idea and decoherence, that the more you bump into things the more you restrict the definition of the wave... the weight characteristics of that.

If you did not have this kind of... and again I'm grantedly absolutely a heretic on this point... I think wave observation and collapse is the most common operation in the universe and is actually the *basis* of classical matter, that without it if you didn't have the proton continually observing the electron, the electron continually observing the proton, you wouldn't have an atom, and when I say observing I mean they're accelerating each other. When you accelerate each other... and by the way, it has an interesting connection with this whole idea of frames. Acceleration is changing the inertial frame of the other particle.

So, items like atoms depend *enormously* on what we would think of as quantum observation but at an *extremely* simple level. If I accelerate something else, I cause its wave to collapse. That collapsing process is where you get this *marvelous* idea of matter that can exist and have this spatial definition (this difference). So, I would say it's co-emergent in the sense that somewhere reality configured itself so it could sort of, like, keep banging on its own head at a very small level, and that banging operation, that acceleration process, is continually allowing things to have an existence.

You take that same atom, you throw it out in empty space, this proton and the electron still know where they are, they're still accelerating each other, but until some *larger* entity, some larger frame, touches that atom again, it's a wave, or it's what *we* interpret as a wave. I mean that's a really interesting issue about just what a wave is in an ether-free universe. The idea of a wave in an ether-free universe is... gets really interesting, but that atom, again, becomes quantum, and we see this in some of the quantum mechanical thought problems.

You see a large molecule equal to about four DNA codons. Can it go through two slits at once? Well, how's that possible? The molecule sees itself. It accelerates itself. It has an internal structure, but the *presence* of that structure in the *larger* frame can be ambiguous. If there's no bumping, things get very wonky with this definition of space and time. That's where you get these things like interference even of fairly large molecules. So, quantum perturbation, which fascinatingly goes right back to this idea of what is acceleration (because acceleration then becomes observation at an *incredible* range of scales, not just tiny) gives us this state machine, gives us this ability to localize, to suddenly *not* just be a nebulous set of things, and I think that's a certainly an area I would *really* want to look at more closely, and as I mentioned the idea before I think there's a symmetry break of some kind going on.



There is a disruption between what *we* think of as momentum-energy space, and **time distance space**. I think at one time in the infrastructure of the universe those things were equivalent, that they were actually... had the same properties. So, I think there's just... there's an intriguing possibility that *that's* the symmetry break that allowed these things to co-emerge and enable the distance concept that makes the state machine substrate possible, and also the time concept at which you can change the state machine. Meanwhile, the momentum space plays this kind of bizarre maintenance role of keeping these things going and preserving the energy. So, fascinating possibilities on that. Co-emergent!

[1:34:54] RB: Alright... Uh, that is fascinating. One can even *muse* on when you mentioned symmetry breaking. Now, I think of symmetry braking differently, but if you think of momentum-space symmetry breaking, when we... in other areas of physics (including quantum field theory and group theory) apply to it, of course, symmetry breaking implies emergent... essentially mass creation basically, like, has it like a Higgs-type mechanism, so one must... one might wonder if in your model whether you might get mass (real mass, in your case) out of this apparent symmetry breaking between the moment—... let's just say momentum and space, so that's—

TB: Yeah, yeah.

RB: — conceptual speculation. That's nothing. Nothing solid.

[1:35:46] TB: ... and I would... The symmetry breaking... The difference on it would be that the symmetry breaking... Well, not a difference, but the symmetry breaking would be attached *to* the individual units of matter. So again, there's no *broad* space concept, but there's *something* going on where some kind of *thing* (because obviously we're *here*) is breaking apart in the this fashion that produces new behaviors, so... Yeah.

[1:36:17] RB: Okay. Finally, my last question... I apologize to the other listeners for monopolizing the time here, but your prior comments segues nicely into this: How does entanglement fit into [your SMU model]?

[1:36:35] TB: Entanglement, and also things like the double-slit interference of large objects... all of these become consequences of the state machine being unable to define what we would think of as space and time. This state machine... This is where it would be interesting. A state machine has a concept of change and of storage, of separation, that is not necessarily the same as what we think of as space and time and it's very important to make that distinction.

So, when I say there's a state machine, I'm *not* saying it's a changeless machine or that it's a machine that has no concept of separation. I'm saying that the very extraordinarily *precise* versions of separation and change that we see that we call space-time... those are emergent from some simpler set. Now, once you say that, what happens is that issues like double-slit experiment, entanglement in general... those become cases in which the transition between that lower form of change and separation just cannot map into the classical definition of space and time, and we know this observationally to be true because we *have* things like entanglement. We *have* these strange interference effects that go on, but it's a different way of looking at it.

It's just saying that the problem is that you cannot construct a space-time capable of accommodating those results that you observed. Those results don't fit your model, because they were done at a substrate level that's more in the state machine and less into the emergent behavior that we like. We don't just like it, we wouldn't be here without it. I've said this before on other ones that classical physics should not be derided as an old way of thinking. If it wasn't for the emergence of classical physics we wouldn't be here.

You know, classical physics gives us particles by this incessant collapse of the wave functions that probably shouldn't be happening in a fully symmetric universe. It gives us this ability to expect things to stay stable and it gives us (more than anything) the ability to store something called information (the idea of persistence of configurations over time). All that comes with the emergence of classical physics from this substrate and one of

the things I would *really* like to have a better feel for is how that substrate works, because in that substrate our usual definitions of separation don't apply, and another example I give beyond entanglement...

When you say this electron on the other side of the universe is identical to an electron here, what does that statement even mean? Does it mean they were actually *literally* replicated or was just the *image* of a single electron relocated to an enormous span of space? I would lean towards the *latter*, that there's some kind of universal definition of electrons, because these things are all exactly the same. They don't evolve, they don't mutate, they're just absolutely identical across the entire universe and that is *remarkable*, because if you use cloning, that doesn't happen. You get mutations.

The only way you get the kind of absolute identity across the entire universe is that you have to have virtual imaging, again, using a computer science term, and I think that's a clue to us (that's a hint to us) that there's a substrate that in *some* perspective if you look at it... and this is actually an old Wheeler idea, that there's only one electron, that one electron is going back and forth in time was his version and Feynman marvelously interpreted it in a more practical way and came up with QED... but it *is* reminiscent of the idea that there's... these relationships get set up, then information allows them to be imaged in different ways, but they still retain that deep integrity, and again, go back to the example.

If electrons were just being copied, duplicated, and spit out everywhere, in every other case in nature where that happens you see mutation. You see them evolving, you see them devol—... changing over time, and we don't see that at the particle level of physics, so it's telling us something deep about the substrate infrastructure.

[1:40:55] RB: That's extremely interesting, because even apart from your SMU model I had actually raised (some time ago, some years ago) the question of whether entanglement means we need to reconsider the whole concept of identical particles and statistical mechanics and quantum mechanics. It's—

TB: I would agree with that.

RB: Yeah, I mean, it... To me it almost implies... I'm thinking of something like a subway system, which could also be considered a substratum... that there has to be some kind of an identity tag to those particles or whatever in order to have them entangle with each other and not be self-entangled, so to speak. So I do want... that's a very interesting discussion. Yeah—

[1:41:38] TB: ... and I have to point out on that that if you look at the definitions of bosons versus fermions (just the deepest definitions of the wave function). We got one solution gives you fermions, the other gives you your bosons. All of that is based on the idea that if there's nothing to distinguish the particles they are the same. So, our quantum physics in a very deep way is *already* based on the idea that all electrons are the same electron. It's almost... It's built into the math, but I don't think we carry it to the limit of saying, like... well, that's true in a tiny little system, because it absolutely is. I mean, if you have a small system you cannot distinguish between those electrons unless there's some characteristic that's added to it (spin, orientation, *something* to distinguish them).

That's a *fascinating* thing and I think part of this broader insight that that effect *somehow* extends to the entire universe, and again, I would invoke this breakdown of symmetry between momentum and location. The momentum space somehow must be involved with that, but in which way I don't know. Octonions... anybody out there who likes hyper-complex numbers... Look at Octonions, because that would be the mathematical framework that most intuitively would break down into two asymmetric spatial definitions.

So, sorry. Just had to elaborate a little bit on that.

[1:43:04] RB: Oh, thank you. That is... That's quite interesting. In fact, I would comment that as you seek to move from Minkowski to Euclidean space at the same time that the heart of that is that complex... what do you



call complex... the complex, CRU... What did you call it? The mathematical representation of a complex number of the... yeah. It's interesting that you kick it out of Minkowski space, but you kind of introduce it at a more fundamental level, so it's interesting that the complex element re-enters, but in a very... in a more self-stratum way, so to speak.

[1:43:46] TB: I had... This was just a couple weeks ago and this is some of this kind of fast moving. I started with tilted block models, was going over with my son, who's good at math, about different representations, matrix representations of the rotations, and then we suddenly realized that we don't need to make... just use imaginary numbers, just use complex numbers, and all of a sudden the entire model collapsed into a multiplication of two complex numbers.

That can't be a coincidence. There's got to be some kind of connection between that formulation of special relativity and quantum mechanics, because it just seems eerie that they would come to such a simple similar conclusion with that, and my only debatable point is I'm not sure... Again, I would love to play around with using the *real* axis as the time axis and the other axes as the three-dimensional time, because that still gives you that same behavior for that particular case, but I think there's some really interesting math possibilities.

RB: Alright, I yield the floor. Thank you.

TB: Thank you.

[1:44:57] TX: Actually, I got a question from Lou. He asked "How is this affected in an expanding universe?", but I'm not sure what he's referring to. Lou, can you unmute, or can you ask a question again?

[1:45:14] TB: Well, that is an interesting question by itself. An expanding universe... Oh... Something we are doing in our universe has an incessant forward drive to it, and this is where I go back to that Speed model [referring to the 1994 movie *Speed*, about a bus that is rigged to explode if it ever stops moving or slows down too much]. I just, again, the intuitive thing about the Speed [movie analogy] model... You either go in loops or you go one way or you go the other way, but *you gotta keep moving*, and that says that there's a larger structure that is expanding our universe, and actually this is something that's coming up on one of my future videos, where I talk about quantizing gravity.

It's [that] I'll talk about dual universe models of quantizing gravity, because I think... I am a dual universe advocate. I think that the symmetries, what they call the CPT symmetries, *cannot* be fully reconciled unless you have... you wind up with two universes, and the two universes then *attract* each other.

One way... One analogy I like to use... You think of a virtual pair, you know... We all hear about virtual pairs, you know, the electron, the positron... They come together and then they go back together. Well, think of that on a *cosmic* scale. That you got two universes (or two sets of complexity) that push apart and then one of them (or actually both of them) invent this little concept called time, in which basically they get so messed up they go "I don't know how to cancel anymore. Crap. What am I gonna do?"

So they just go *shooting* out this way saying "I don't know how to cancel.", and by the way the cancellation I'm talking about... I'm talking about *hydrogen* atoms, because when you put an electron with a positron... An electron with a positron *cancels*. You put an electron with a proton, everything messes up. Everything messes up! Suddenly, it goes like "I can't... What? I can't cancel." So these things go *shooting* out with this definition of time, but eventually they're gonna have to come back together.

So, the expansion of the universe somehow is involved with this and I think that's why we have this structure that we're not seeing that is a broader structure that helps create these different definitions of that. So yeah, it's a *great* universe and I think not only are we expanding, I think eventually... Penrose thinks that we'll... the universe will end in just a loss of scale, and I don't see that because protons don't... you know, protons [and] electrons don't



lose scale. They just... They're persistent, nagging on that, but I do foresee a possibility of a big *poof*, that we come back together with the anti-universe and things go bye-bye.

So... and there's probably some astronomical observations that you could make that would *tend* to lead [one] to say that that's probably *sooner* than some of the other scenarios rather than later. So yeah, there's all sorts of interesting issues there

TX: ... and I got a question from George **Sipolland**. Do you have any comment on [the] Cavendish experiment measure? Remind me what was Cavendish? Cavendish...? I'm sorry. I don't remember. I remember the name. I don't remember what the experiment was. Can you remind me what it is?

TX: George?—

RB: That was the 18th century... an 18th century gravitational experiment trying to measure the... what was it?... gravitational—

[1:48:38] TB: Oh, that was the one I showed.

RB: ... the [initial measurement (?)] of the gravitational force, I believe it was.

[**Transcriber's Note:** [The Cavendish experiment](#) was apparently the 1st experiment to try to measure the gravitational force between two arbitrary (relatively “small”; not planetary) objects.]

[1:48:41] That was the one I *showed* wasn't it? Yeah, the Cavendish experiment... My only comment on the Cavendish experiment is I think *really*... somebody *really* ought to check that experiment out in a highly accelerated frame and see if there's any detectable difference. You know, if you had... I think that might be doable. I mean, just the idea, for instance, in an... International Space Lab. If somebody could do a Cavendish experiment with exquisite detail and look to say “How does all this motion and gravity affect the ability of those things to go together?”.

I don't... I have not done a literature search on that. Usually, I would have done a literature search before I even said that. I have not, because that was an idea from like two days ago, but I think that's an *interesting* issue, because... Does gravity?... Is gravity invariant under special relativity? I would say *yes*, but *saying* that places gravity in a *different* relationship with special relativity than what you might expect, and if gravity is *not* invariant under special relativity: *wow*, that's a finding all by itself. So either way that would be an *interesting* experiment to see if there's detectable levels of change due to special relativity on the Cavendish experiment. No wonder that name sounded so familiar. I grabbed a more recent issue, but I was thinking, like... Cavendish? Cavendish? Remember...

Anyone else?

[1:50:18] TX: Williams Slater, do you have a question? [Can] you unmute?

CP (Caetano Peng, not William Slater): Yeah, I've got... Can you hear me?

TX: Doctor Peng, yes.

CP: Yeah. It's just [a] simple question. It's about this nature of time. If time is a kind of rate of change, and the smallest time is defined by [] Planck's constant, then [] infinity shouldn't exist at all. How do you perceive the role of the Planck constant on your model of a state machine—



TB: Yeah, Planck's constant... No, do you mean Planck's constant or do you mean Planck *units*? So do you mean, like, Planck scale?

CP: Yeah, plank scale. Yeah.

[1:51:13] TB: Thanks again. Yeah, because [Wheeler](#) had a concept and he had a different name for it, [Arid](#)... I don't know. It had an interesting name, [Aerons](#) or something. Wheeler was the one who first came up with that and basically he did an extension of the calculation saying that if you take all these things to a certain scale you should get this Planck unit that has the weight of... what... around an amoeba or something like that? It's pretty *massive*. It's pretty massive at a certain size and scale, a very tiny scale.

The simple answer to your question is that if you go with a state machine model in which the state is only maintained by systems of mass and energy and all other information is *excluded* (which I do, which is what I'm doing) then you don't come up with Planck foam. You don't get Planck foam, for the simple reason that you can't put enough mass energy into one spot to create an instance of Planck foam.

As a conceivable limit, it still exists. So, in that sense... I'm not saying that you can't have a Planck unit, but the trouble is this: that a state machine model is very rigid about the amount of information required in order to define the unit. So the amount of information that would be required to create one Planck scale unit would be comparable to the total mass estimated for that unit. So, you get this fascinating thing.

It's not that you couldn't create it, and maybe it would have really interesting properties. The assertion is that in a finite state universe those are not the fundamental characteristics... Those don't mean anything for the overall structure. They might give you some *insights* at some level, but they're not part of what's going on all the time. The... All action is in the actual information that you would be having, so... There... I won't say they're totally, completely incompatible, but it certainly puts a different spin on it. It becomes just like particle accelerators. You know, the particles you see don't occur normally and that would be an *extreme* example of that.

[1:53:23] CP: Yeah, thank you.

TB: Bill, did you have any... Did you have a question, Bill?

[1:53:28] WS: No, I just... Well, I had a question and a comment really. I put a link in there to the TCP finite state diagram, which I love, because I've been involved in networking for over 30 years, but I'll work with you if you want to on this, but I think it would be useful, if you talk about finite state machines, to actually show an example of this in a visual diagram.

TB: I would agree with that and this, again... ever since the tilted block formalism this has been kind of moving quickly in some directions I didn't quite expect. So, the finite state... The FSU [idea] is only like a couple weeks old, and... but once I glommed onto it, I... boy, I don't think I'm moving away from it, because it *just* makes some of the math *so* much easier. So yeah, that was a good example and yeah please feel free to send me some examples.

WS: Good.

TB: Thanks.

WS: Wonderful job, though, Terry. Thank you so much.

TB: Well, thank you Bill. Anybody else?



[1:54:41] TX: I've got a good comment from Lynn: "Terry, this was a fascinating presentation. Your state machine perspective on emerging space-time resonates strongly in my own research where I explore how a specific geometric density of space can generate the constants we observe.", and Lynn will be presenting on December 20th.

[1:55:03] TB: Oh, okay. Look forward to seeing that. The... Yeah, the state machine model is... It's fun partly because it just makes some of these issues much more tractable for saying "Well, if even space and time were defined by operators on models [then] I can do that with a computer, I can get an idea of what that looks like, so you get some really interesting *modeling* opportunities that you might not get in some other models, and there are cases where models that I've worked out do get slightly different results from the lead nuclei collision models that they use, for instance, at the Large Hadron Collider, because they've introduced a time gradient and the models they use don't address that time gradient, so that's getting *really* deep in the weeds on doing it, but it's still a real difference and these models are ones that are tractable to computer science background folks. So, computer science could... and I didn't plan it that way. Boy, I didn't plan it that way, but there's an opportunity there.

[1:56:15] WS: Hey, Terry, real quick... part of the politics about how the Hadron Collider wound up in Switzerland is when the Bush 41 administration tried to get that through, and put the Hadron Collider in Texas, Congress decided not to fund it and so if Congress *had* funded that, if we could turn the clock back to the early 1990s, the politics of the development of science might have been a lot different. It might have actually happened in Texas instead—

[1:56:53] TB: I remember that. I remember that well, because those giant holes they dug. They actually got to the point where they dug giant holes, and then they defunded it and that was the point where the US pretty much abandoned the deeper research.

WS: Sure.

[1:57:08] TB: ... and by the way, that... I *love* some of that research they're doing. Some of the stuff they've done with the large lead nuclei collisions... There are certain detailed characteristics. Again, I'm getting *really* down in the weeds, but some of them are not well explained and I think models... I've got to go back and look at that, because I do think some of these ideas can help give some kind of explanation maybe for some very specific characteristics that they've found in some of their data.

[1:57:57] WS: Sure. I'd also like to add (since I'm here in Chicago) two things. One is: if you go look up IQMP.org you'll see that we are putting one of the largest quantum facilities maybe in the world but definitely in the United States, on the south side of Chicago, where the US steel plant used to be, so that's IQMP.org, and the other thing is on... I think it was on November 3rd and 4th, we had the Chicago Quantum Summit 2025 here, and one of the things... They had the deputy, gosh, the Deputy Director of the US Department of Energy, which is where all the quantum work is happening in the federal government, and this is very, very interesting.

He announced two things: One is that we're going forward and the Trump administration is funding about \$750 for quantum startup development, and this is very, very encouraging because basically they just came right out. They just stated it. They said "Look, if you've got a quantum startup we do not want you starving. If you're a CEO, if you make an application, if you've got the right credentials and experience we will fund you for your first year, a \$115,000 salary, plus we will give you \$150,000 in operating expenses for your first year."

So this is fantastic news and I want to emphasize that the other thing that I have knowledge of is that the Indian federal government is putting a similar \$750 million into *their* quantum development over in India, so I just thought that it was interesting that those two numbers (\$750 million) coincide and I have a funny feeling (because I know a lot about the economy of India) that they're probably going to get a lot more for their \$750 million than the US government will, but I'm very encouraged that the United States decided to play catch-up against China

and say “Well, we’re going to put our money where our mouth is because we want to lead this quantum race.” So, I think it’s bright times for the quantum world.

[2:00:08] TB: I did *not* realize they were funding that and I am a *strong* advocate of small company and individual researcher funding, giving unfettered funds where they don’t have to worry about eating, because just look at the track record. That is always where we get the *really* interesting innovations. The bureaucratic structure of large companies, bless their hearts, it just doesn’t promote that, because you get too much internal competition, people start worrying about “Hey, you’re gonna damage my market if you do that.” and that’s a very real thing.

So, *that’s* where you get your innovation and [the] quantum field is just... I’m a bit gnarly on some aspects of the quantum that I think we should be taking some very different perspectives on that, some of which I’ve just given. I think a state machine model gives a very different twist on how you might interpret that, but the computational possibilities there are *just* intriguing, because the universe isn’t working only by conventional computing. It is most certainly not, and living organisms I would argue at the cellular level (with the behavior of biomolecules and the way they pull this little trick of pulling certainty out of chaos) appears to be a quantum-related phenomenon, and we don’t understand that yet and I just think there’s just *immense* potential in that and clever minds, individuals, unfettered, able to look at it and look and say “What’s going on here?”... So I’m glad to hear that there’s funding going to that. I think that has potential.

[2:01:49] TX: ... and I got a question from Ron. Is the stain machine model [a] deterministic or non-deterministic state machine?

[2:01:59] TB: It is deterministic at large scales to the degree that we can perceive it; in other words, when you get into the classical approximation. So this is kind of like 1900s physics. At that level, it becomes... In fact that’s one of the reasons why they were so sure they had physics wrapped up is because basically they were looking at a state machine-like model of: You’ve got the rules of physics. You’ve got the matter and energy. You do the transformations and there you go.

So, a state machine model in some ways is *not* that radical, because that’s kind of where they were at back at the end of the 1800s. Why do we have to use one number difference on our century *labeling*? Okay, so... but around, you know, late 1800s that’s where physics was going. So, the trick is that you gotta be *very* careful when you get small levels, because the quantum uncertainty in a state model is just lack of definition, and again I would say... Now, it is more complicated than that, but it’s just saying that if you get too small then you start getting fragmented space-times, you start getting non-interacting space-times, you get structures like I said.

The spin one-half particle I would say is an actual instance of space-time and that’s a heretical statement, but after looking at spin issues I’m also quite convinced that that’s part of why it works. It has its own definition of rules that are different from the rest of us and then you get these things going. So, small scale, no. It’s not deterministic. Large scale, it gets more and more deterministic the more features you have that follow classical observation, but it will never get fully deterministic.

[2:03:47] RS: So, if I could follow up on that, at the small scale does that just mean we just don’t know *what* the other states are?

[2:03:58] TB: It means that at the small scale the other states don’t *exist*. So it’s a little blunter than that. This is the sparse information universe. It’s saying that if you don’t have enough information, the... There are emergent possibilities and you always want to keep that in mind (the idea that things... behaviors can emerge from, like, an electron floating in space), but, you know, below that level instead of having superpositions of infinite numbers of infinities of things, you just have a *stable* state and the stable state *is* the state, which we haven’t done (I think) a real good job of defining, but we can define the *potential* of that state by using particle models and by using quantum field theory and we make some *marvelous* predictions.

So the two have a relationship, but it's important not to think that those internal things are anything more than *sampleings* of that state. If you notice, whenever someone says that, for instance, an orbital is a superposition of an infinite number of electron states, what they always mean experimentally is if I *poke it* I will see an example that looks like one of these states. If I poke it again I'll see another example. In other words, a sampling theory.

So you use the sampling theory, you look at all that, and you wind up with this conclusion and say "Overall, it *looks like* I have all these things involved in that." You want to make it... You want to be careful about that distinction, because observationally it *never* happens. You don't get all those things at once, *ever*. All you get is the samples, but you can develop... You can use those samples to develop a model of your overall behavior.

So there's this really interesting relationship between very traditional Quantum field theory type things (because it works... you know, it works very well) and this idea of what is the *reality* of that at a lower level? Is a pion actually... Is a proton actually a bunch of quarks floating together? Or is it a stable state in its own right? And I would lean towards the latter.

[2:06:01] RS: Thanks. I think this is fantastic. I mean... State machines are well understood by people outside of quantum physics or quantum mechanics, so this is really great.

If I could just add a following comment to Bill's mention of the Chicago Quantum Summit, which was sponsored by the Chicago Quantum Exchange and was held in the Willis Tower down in the loop. It was a very large entity this year. It like quadrupled in size from last year. It was probably 800 people at this event. I was there. I sat in the front row. I tried to get Governor Pritzker's autograph, but he got shoved off pretty quickly, and I was really impressed by the gentleman that Bill mentioned, a sub-secretary of commerce I think he was. He was one very, very well versed in quantum.

So, a lot of the money of that \$700 million is going to be under the control of, like, the DOD or the DOE, so if you guys are... and they... There was one mention of a program *here* in Chicago based out of Argonne National Laboratory where they had, like, what you were talking about, Terry. If you can get hooked up with them they pay you a salary plus give you access to their lab facility and their lab. You know, they give you space in their lab and access to their equipment. So it's... that to me was the highlight of that funding, so...

[2:07:54] TB: ... but cooperative access to labs... This is something we used back on the program that I was involved with. You can get some *really* good... You know, you have these *marvelous* facilities. Sometimes they wind up not being used that much and you get private-public liaisons between those to make a good directed use. So, like, for instance, some small creative innovator can get access to those to try out some wild and wonky quantum theory idea that he might not have other tried and I *encourage* individual researchers to do that again. That's where the innovation comes from. It's just the track record is just undeniable.

Smart people who have a good idea of what they want to do. It may be *very* different from what other people are doing, but they believe in it and they're methodical about it. You know, it can't just be a totally random idea, but they have something where they want to go with it. I have seen... I've talked to researchers who've done just... I remember one guy, I had to talk to him for I think a full hour on the phone before I *finally* glommed on to his idea. Either dumb Terry or maybe he wasn't explaining totally clearly, a little bit of both, but then when I *realized* what he was saying I said "Oh my gosh, that's gonna *revolutionize* that little bit of what you're doing, and by the way that technology is now a part of every feature of the internet these days." So, but... There's an opportunity there and if you can get that kind of funding and do it I'm... It's good possibilities.

By the way, I like your symbol. I always like your B symbol there.

RS: Thank you.



[2:09:32] TB: ... and Bill when... Now I'm going to have Jim Croce's Leroy Brown in my head for the rest of the day, because you start out with "South Side of Chicago" and now I can't get it out of my head. So—

WS: That's hilarious.

TB: That is part of Quantum Town so, you know...

WS: Yeah, rest in peace, Jim Croce.

TB: Yeah. Okay, other questions?

[2:09:55] CP: It's more... maybe not physics, perhaps more geared towards philosophy, maybe philosophical kind of question: On earlier slides you mentioned about space-time fabric and its relation to energy and mass. Now, suppose that the mass and energy are absolutely still. No change. That implies that [the space-fabric] would collapse. Is it correct?

[2:10:29] TB: The way that I'm defining the state machine here, something is *absolutely motionless*... First of all that *can't* happen, because if you take quantum oscillations into account, if you have an atom that is at... I think you can postulate an individual atom that is at absolute zero. You certainly cannot do it for a collaboration of them. You can just approach it, but if you imagine an atom or a single particle that is at the *lowest* energy state imaginable it still has quantum spin. It still has the spin that we talk about (the half spin, the whole spin). That is a dynamic quantity that *changes* over time.

So, the first thing that happens is you *cannot* have that concept of being *totally* at [rest]... motionless, which is why I keep emphasizing the fermions. Fermions with their half-spin seem to have something critical to do with that. They provide a structuring and a separation ability. The exclusion (Pauli exclusion principle) is the simple way to state it. That is critical for providing an overall solution that has retention of memory.

So, no, your space-time fabric would not collapse. You would *still* have these particles. You still, for instance, two fermions that are in the same state, they would still repel each other. You know, and of course that would be an energy potential so you'd wind up having the fermions infinitely far away from each other. You get in all sorts of things, but the universe as it's given to us just does not allow fully static [(i.e. unmoving) objects]. We get the *illusion* of it when we travel only in time. We can make structures that seem very, very localized physically, but they're still moving through time, and you can't... That's the Speed [(1994)] movie model again. You know, I just... They wind up doing that little spinny thing and off they go.

Yeah, Bill?

[2:12:26] CP (Caetano Peng, not Bill, regarding prior response given by TB): Yeah, thank you.

[2:12:29] WS: Yeah, sure. I'd like to leave you guys with a final thought. You know, there might be some people that come up with contributions after this, but my wife and I spent Thanksgiving a week ago in Acapulco. My wife and I don't have any kids and we just celebrated our 25th anniversary on Wednesday. So, we're... you know, we're world travelers, but let me tell you what I observed in Mexico. The people down there are just as sweet as possible. We were in Acapulco and I want to emphasize something. I don't like to get into politics. I mean I can talk politics, but it's never popular in a big group.

Despite the tone of some of our national leaders about Mexico, those people down there have no guile [towards] our agenda, toward the United States. They're just as sweet as they can be, and so it occurred to me when I came back, and I've already reached out to a guy that was in our Australian quantum group, a guy named Joseph, who's from Mexico. Those people are very hungry for the stuff that we're sharing in this very webinar right now, and so



my español is poquito. I know how to be polite in español and stuff, but I can't carry on an extensive conversation, but I'm very concerned.

I want to make sure that our closest neighbor Mexico (175–180 million people) have access to the stuff that we're doing today and so... I'm gonna do my best to start up some Mexican quantum user groups, because I want to make sure that we bring these people along, that there's no dividing wall between the United States and Mexico in terms of knowledge, so I... You know, that's one of my little side projects, but even though I'm a español impaired I'm gonna help those people, because they're wonderful neighbors and they deserve our help.

[2:14:43] TB: That is a *great* idea and... That's a great idea, and again, individual innovators... Individual innovators are everywhere, *if given the chance*.

WS: Right.

TB: ... and they cross all national boundaries. They cross all of the weird divisions that we make with each other.

WS: Right.

TB: It's just... People who have a fascination with some problem and they can solve it, they are where you find them. So the more they have the chance to do that, the better. So I think it's a great idea. Machine translation certainly helps these days, because that is an area where we've made *huge* progress, at least with European languages. China... Chinese is still a little dicey sometimes on the model (the translation), but we're making good progress on that.

Also, when you said that, I couldn't help but think of the Astrophysica group that I used to participate in during COVID. *Marvelous group!* Roger Penrose showed up every week with us and was there asking questions. It was just a *marve...* and by the way, most of the tapes with Roger Penrose on them are gone now. For some reason, they got deleted. Yeah, yeah, seriously. They got deleted. They're not there anymore, at least not *openly* available.

So, I think it was just a terrible loss that a lot of those tapes are not there anymore, but just some really fun conversations and I think good exchanges of data. It was all done in English, but I love the fact that it was, you know, working with the observatory groups down in South America. So, yeah, that kind of exchange is great.

Someone said genius doesn't have skin color. *Yes, amen!* Oh my gosh, the distinctions humans make on a genetic basis are *so* bizarre, because *none* of these ideas people have of race really correspond to the actual genetic distributions of *anything*. So, to say they're arbitrary... You know, humans are very mono... We have a very *narrow* gene pool actually, and you compare that... There are mice that have like 20% diversity in their gene pool in their same species and ours is, like, I don't know, it's incredibly tiny. So, yeah, this is *very* artificial stuff.

Yeah, Bill?

[2:17:11] WS: Yeah, I wanted to give y'all a perspective. I was one of the founders of the Chicago chapter of the Internet Society and so we had the bizarre experience of having a video conference up at Northwestern University with the... Doctor **Alejandro Pasanti**, and this happened right after 9-11, and so a lot of people, you know, took stock and said "Well, you know... Who are our real friends in this new post-9-11 world and stuff?" and definitely it's Mexico, and so he's talking about "Well, I'm talking to you from the University of Mexico, which is known as **UNAM**." and he says "This was established 450 years ago." and I was polite and I said "Well, Dr. Pasanti, you said 450 years ago?" and he said "Yes." and I said "Well that's pretty bizarre, because in the United States we haven't... We're only about 225 years old." and so in other words they've had culture and art and science and stuff going on over 400 years down in Mexico.



So, I want to emphasize that as Americans I think we have a special responsibility, being the richest and most powerful country in the world, to kind of like reevaluate our stance on the world stage and say “Wait a minute. Along with great wealth and great power comes great responsibility and we need to make sure that we are not... we don’t come off as arrogant to our neighbors, because everybody deserves a fair shake in this world, whether they’re born in a country with a GDP of less than a trillion dollars, because we’re about a \$30 trillion country.”. You know, everybody deserves a fair shake and I think as enlightened internet citizens who participate in groups like this that we need to be aware that we need to reach out to other people without any sort of prejudice and say, you know, “You want to learn? Hey, we’re here for you. We’re a resource for you.”.

TB: Free market intelligence is also the most powerful form of intelligence, because every person who gets a solution who can then *benefit*, as opposed to having it *taken* from them, but just can benefit from having a solution... The networking effect of that as all people work with each other’s solutions is just *enormous*. So there’s this concept of a free market intelligence that is one of the reasons why countries that *allow* people to do what they can do tend to have much better economies.

They tend to have much more powerful use of the resources, because you’re engaging *more people* with smart ideas, and it’s just... it benefits everybody, *including* people who are extremely wealthy, and it’s falling into the trap of thinking that, you know, power for power’s sake... It never works out well. You just wind up... You wind up *undermining everything*.

I’m gonna see, can we get back on *physics*?

Any more physics questions? That’s a good discussion, but there might be people still wanting.

Helen, are we nearing a close here?

[\[2:20:43\]](#) TX: I’m always on. So I can keep the Zoom on until there are a lot more questions.

CP: We’ve been two and a half hours already.

TB: [{laughs}]... Two and a half is *probably* a reasonable shutdown limit.

Great questions everybody! I really appreciate it.

Great conversations and points. So, really enjoyed the session.

TX: Yeah, I’ve got a good comment from Jordan: “Thank you, Terry. Great presentation. Lots to think about things.”

TB: Okay, thank you.

Computer people out there. Here’s your chance to get into physics: State machines. There’s a path there and I am *not* kidding about that. I think there’s some—

CP: You’ve got engineers too here. No, it’s [not] only physicists. We’ve got engineers.

TB: It... engineers, quantum physicists... If you’re interested in a problem you might be *amazed* what you can do on something like that. There’s some good stories about that. So, shall we wrap it up, Helen?

TX: Sure. So, thank you, Terry, again, and Terry will have the next talk on January 17th at noon. So, I posted a registration on the chat. So you’re welcome to sign up.



TB: Okay, thanks everybody. See you guys next month.

TX: Yes, and next week we'll have another one about neural network[s] in December...

TB: Oh, yes, and you confirmed that it's at 10 a.m. Eastern [Standard Time]?

TX: Yes, in the morning.

TB: I'll check my... I think something got messed up on my invitation, so... Okay. We'll see everybody then.

TX: See you.

