# A Dual-Universe Model of Reality (Transcript)

(Slides embedded with links to video; auto-generated transcript; edits in progress)
(Edits completed for Bollinger Dual Model on Slides 33 and 34)

Terry Bollinger
Presented at: Washington Quantum Computing Meetup (on OrionX YouTube)
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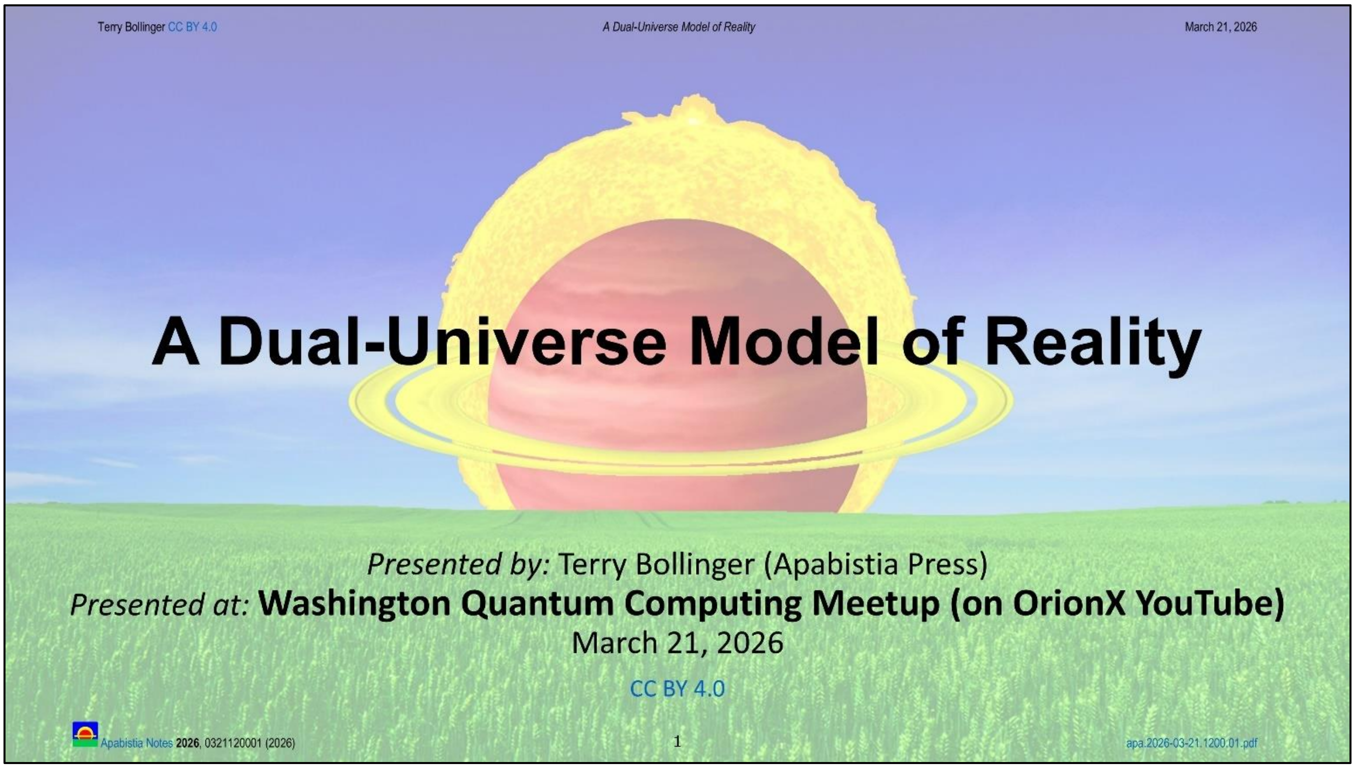
**This is an unedited, auto-generated transcript. You can view the full video at https://youtu.be/YVxOqZxe6kw**



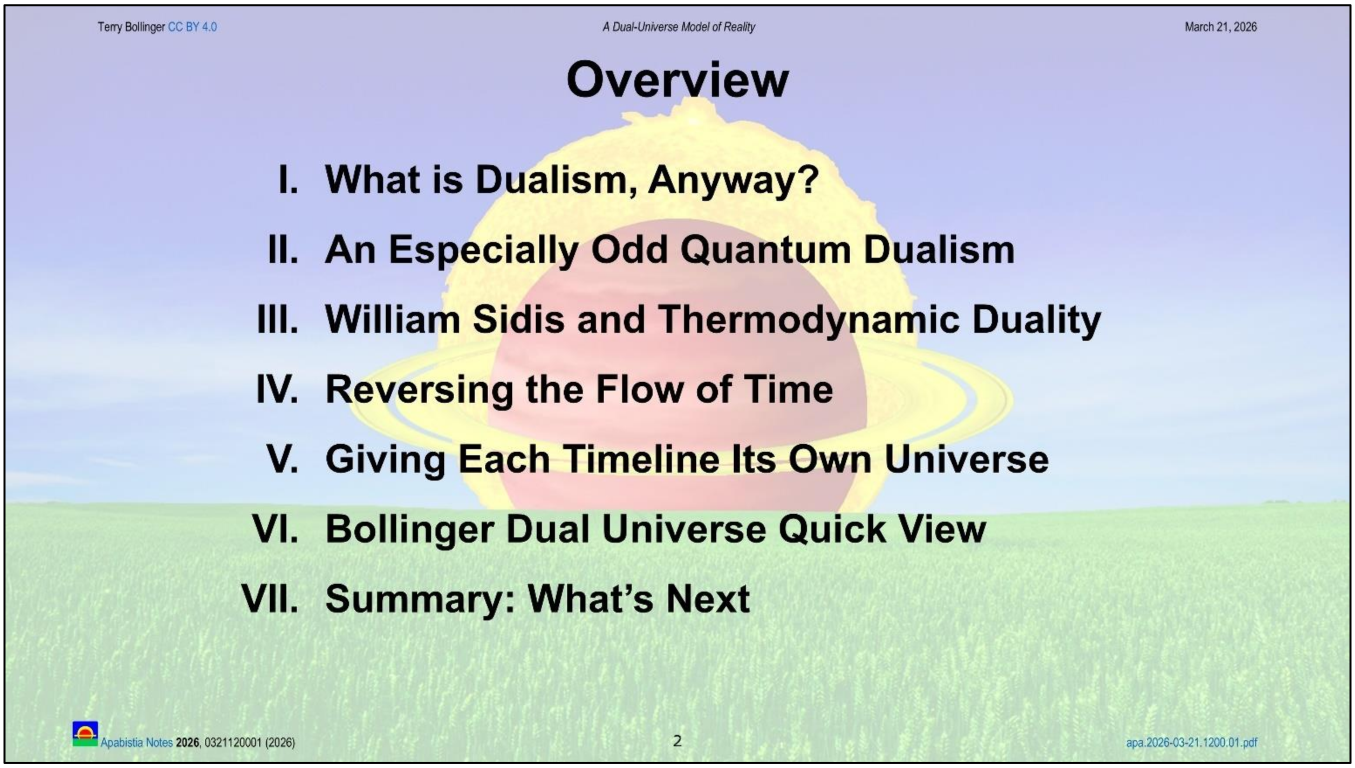

0:00 **Terry Bollinger** (TB) (Speaker): Good morning, everybody, or evening, or afternoon, as the case may be, depending on which time zone you're in.

I'm doing a topic that I've actually addressed multiple times before, because it's been an issue of considerable interest. So, instead of just going over some of my same items that I've discussed before, I'm trying to give a little bit of history of this topic, which turns out to be richer and has more interesting threads than I realized myself before getting into it.

The idea of a dual interpretation of reality in general is very common in philosophical thinking, so people have worried about issues like this for a long time.

Now, where I find it very interesting is how deeply it's gotten into certain aspects of physics. And the way it's been percolating up for over 100 years now, in terms of interpretation of the universe.

So, just some intriguing aspects to the way people think about reality.




1:05 Quick list: I've got seven items this time.

I'll talk about dualism, and a fellow named William Sidis. He's an interesting character. I remember that when I first encountered him, I said I wasn't quite sure what he was talking about. But he definitely qualified as an early thinker about a dual interpretation of the universe, one with a very unique [time] flow — a very unique take — on what he thought that [dualism] meant.

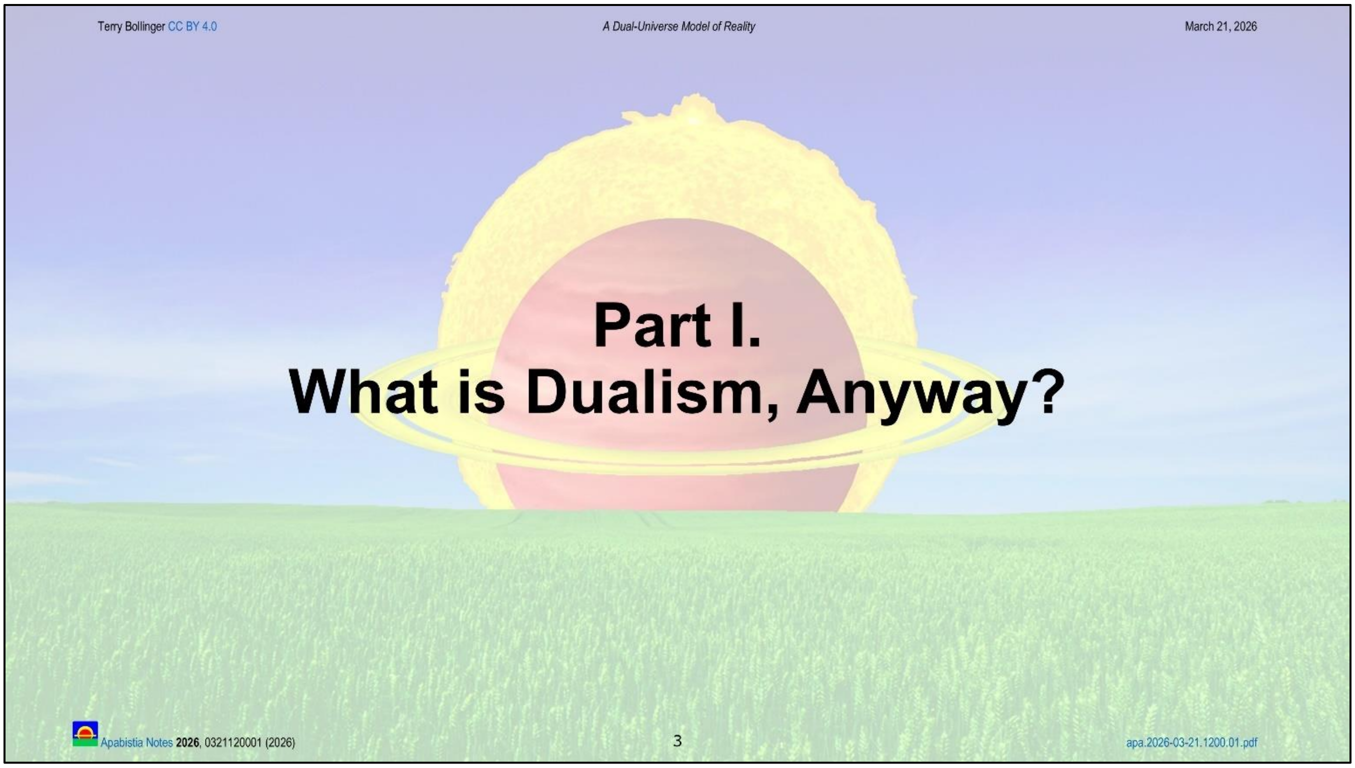
And then you get into what is, to me, the most interesting part of this: the quantum mechanical issues that deal with dualism.

Anytime that dualism touches the issue of time, things get interesting. And it's a repeated theme, and the subject of multiple Nobel Prizes. When people looked at quantum mechanics and the flow of time, interesting and unexpected things happen.

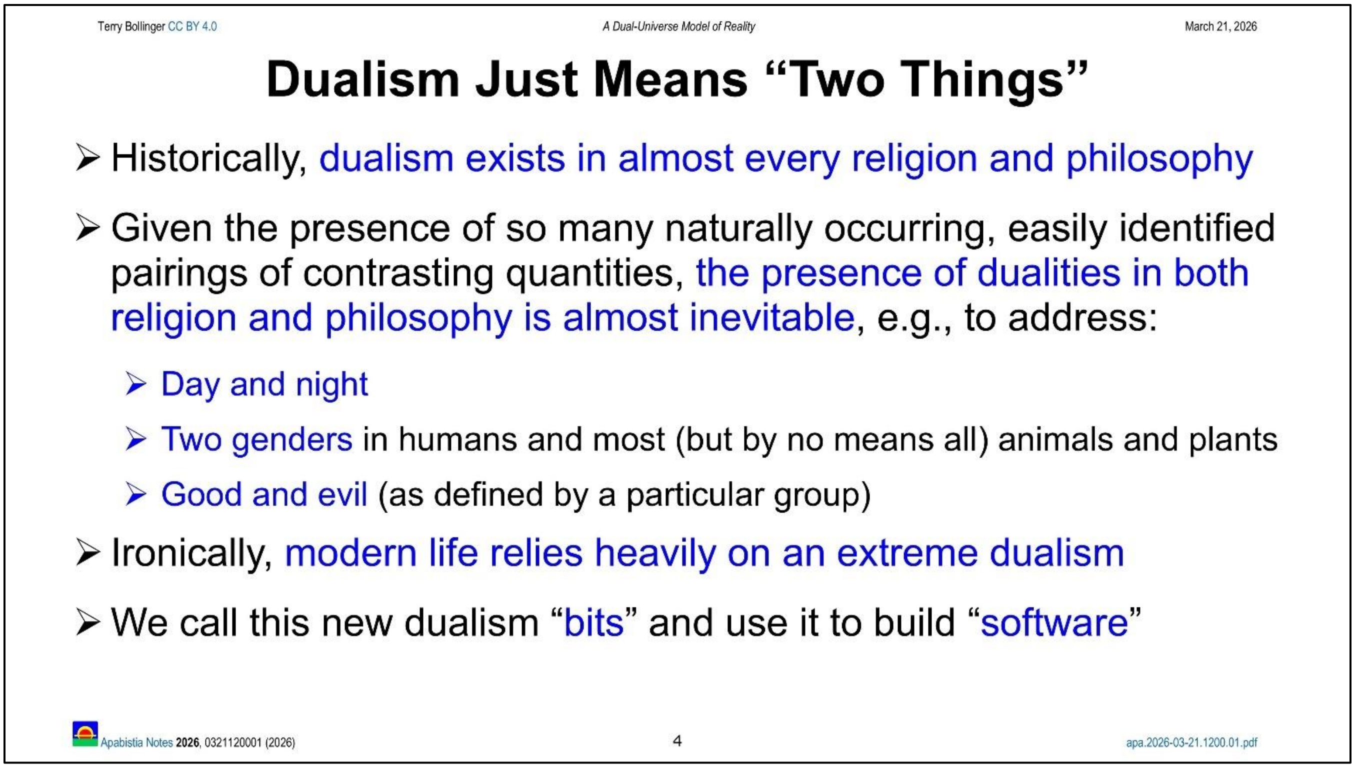
Also, some of the *greatest continuing mysteries* that we still don't really "get" also happen with this.

From a pragmatic viewpoint, understanding how this issue of duality and time works, for something like quantum computing, is extremely important for some of the first versions of quantum computing. I used to tell my friends that essentially it was "dipping in" to a loop of time. That was another interpretation, more of a kind of a many-worlds type thing, back when I was more in that persuasion.

So, you look at this, and the idea is fairly simple: If you can do interesting games with time, not surprisingly, you're going to have an impact on computation. That's still absolutely true, and one of the deeper continuing mysteries about quantum mechanics.




2:49 What is dualism? [First, let's] dive back a little bit, because I think [the history of this concept is important]. … So, what is dualism [in history]?




3:09 It goes back, pretty much every philosophical school that you can find, every religious schools. Often it's difficult to tell the difference between those. When you go back far enough, because people were trying to understand the world, and had a number of concepts to apply to it. One that keeps popping up, though, is dualism.

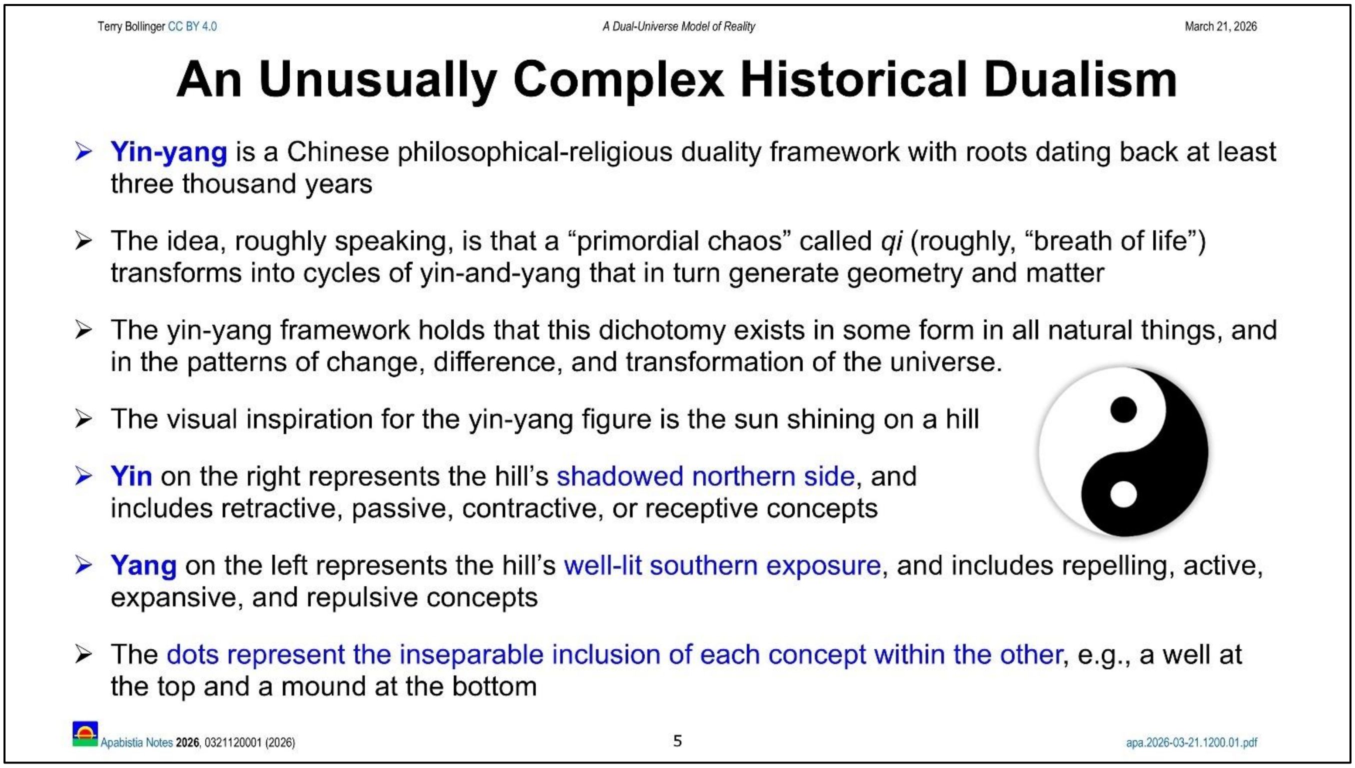
And it's not really that surprising. If you look at the world as we have it on a daily basis, we have just glaringly obvious things like night and day, two different genders, which by no means is that universal. That's something that people should realize. These are approximate dualities, because there are many different strategies in planets and animals that are more complex than that.

And of course, good and evil, which is always difficult to define if you get to the details. What one person says is good often is what another person would say is a very bad thing. So, not one of those simple concepts that you can just do, but it's usually phrased in terms of some kind of dualism — some kind of "this" or "that."

Now, this is just to point this out: What is the most dualistic age of humanity that we've ever had? I would argue that in some ways, on how you interpret it — and maybe, with the growth of chatbots, even more so — we are *in* that age. That's because a "bit" is an *extreme* dualistic concept. It literally says truth, false, this, that, nothing else. That's the *concept* of a bit.

People do an enormous amount of work to make a bit work that way. People do not realize that bits are not trivial in electronic systems. You have to *work* at them. You have to put in error recovery; you have to put protections. You have to work against different kinds of radiation damage. People think that bits are just trivially persistent, and this is not the case.

But once you get those into place, you can combine them in complex ways. You wind up with this concept of software. And if you want to look at some of the confusions that's going on right now about the interface between humans and machines, this kind of extreme dualism is part of it, because the machines don't have these graduated interpretations of reality. They have very much an either-or type of interpretation.



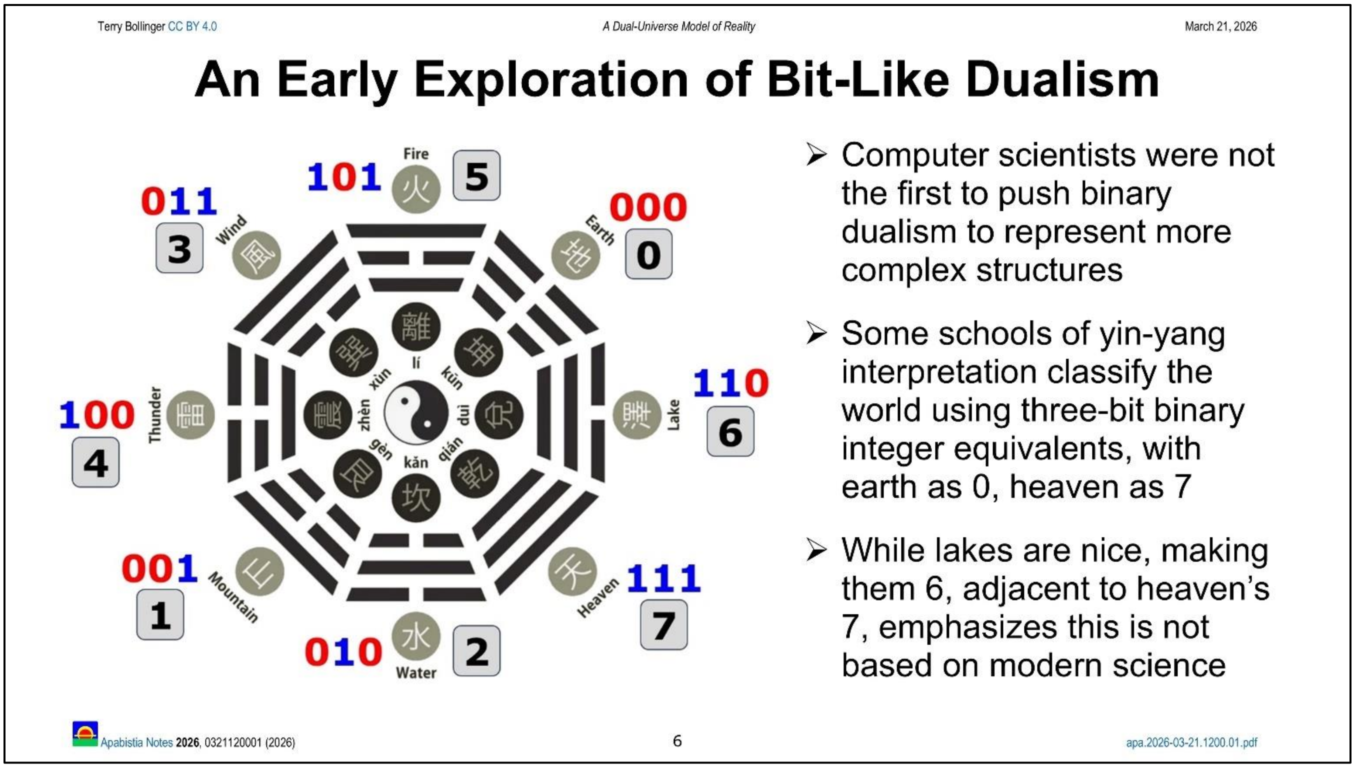

5:30 An example of, particularly, like I say, almost any religion will have this. I will point out the yin-yang of the Chinese philosophical framework. Just because, in part, it's so old, it goes back 3,000 years.

It is not a trivial duality. People sometimes try to say it's just like, you know, good or a bad, some concept [like that]. That we just want to kind of smack on and say, you know, dark and light. It's much more subtle than that. …

There's also an interesting little visual on this yin-yang symbol. Everyone has seen this [symbol]. I had not realized this, but it's actually supposed to be a hill. You have the sun is on the left, which is your southern exposure, and you have the dark side of hills on the right.

And then, you can [also] have an interpretation that there's a well or a hole at the top of the hill, and there's a mound at the bottom, [giving the two eye-like effects]. So it's an intriguing little visual kind of connotation to that [hill]. And [at that very physical level,] it's just saying that the high-energy situation on the left is different from the lesser-energy situation on the right, but they still work together, and they have a role that they play with each other.

So, it's interesting … that [such sharply dual concepts of nature have] gone on for that long, and [with that] enormous [level] of thought and thinking people have put into it.




6:54 One [example in this figure of that enormous amount of thinking that, as a computer scientist,] which I really do find a little amusing, [is that in] one variation of the yin-yang … you have 3-bit binary numbers. You can see those [binary numbers] in these little [solid and] broken bars, where the broken bars are essentially zeros — or, you can interpret them as ones, whichever way you want to do it. It's a dualism.

So you can interpret [the broken bars] as zeros, and the [solid bars as] ones, and you wind up with a sequence of … eight values [coded into] three bits. So, when you talk about an 8-fold way, not coincidentally, that is a total of eight different paths on that [figure].

So, [modern binary dualism] is not the first time people have gone into the pointed idea that there's an either-or kind of dualism that undergirds a lot of [natural] activities.

Terry Bollinger CC BY 4.0 A Dual-Universe Model of Reality March 21, 2026

## Dualisms in Science and Mathematics

- Most of the dualisms of science revolve around the existence of experimentally verified **mathematical dualisms**
- Mathematical dualisms exist when different formalisms capture the same concept or data, sometimes without obvious reasons
- In quantum mechanics, a surprising dualism was the equivalence of Born's matrix mechanics to Schrödinger's wave mechanics
- Two interesting dimensions of dualisms are:
  - Embedded vs. separate: Does nature mix the two forms?
  - Exact vs. broken: Does the dualism look identical from both sides?
- An unexpected dualism can open up powerful new insights



8:01 Now, more interesting, I think — well, I won't say it's more interesting, but more relevant to the part about the physics — is we get into the dualisms in mathematics. [These are interesting] because you have these situations where [dualisms pop up unexpectedly].

One of my favorite [examples of such an unexpected mathematical dualism in physics began] when Schrödinger came out with a wave equation — with wave mechanics — for quantum mechanics. [It's a] very powerful concept, and it took people a lot farther than they had gone before. They were able to represent some situations about the atom that they just had been no explanation for, and the wave mechanics helped [them] do that.

Then this fellow named Born was noodling around with matrices, which were a relatively unknown mathematical framework at that time. And he starts coming out with the same predictions [as Schrödinger].

So, Schrodinger took a special interest in this, and with considerable work — a couple papers on this — he showed that, yes, these [two very different methods, wave equations and matrices,] actually are equivalent.

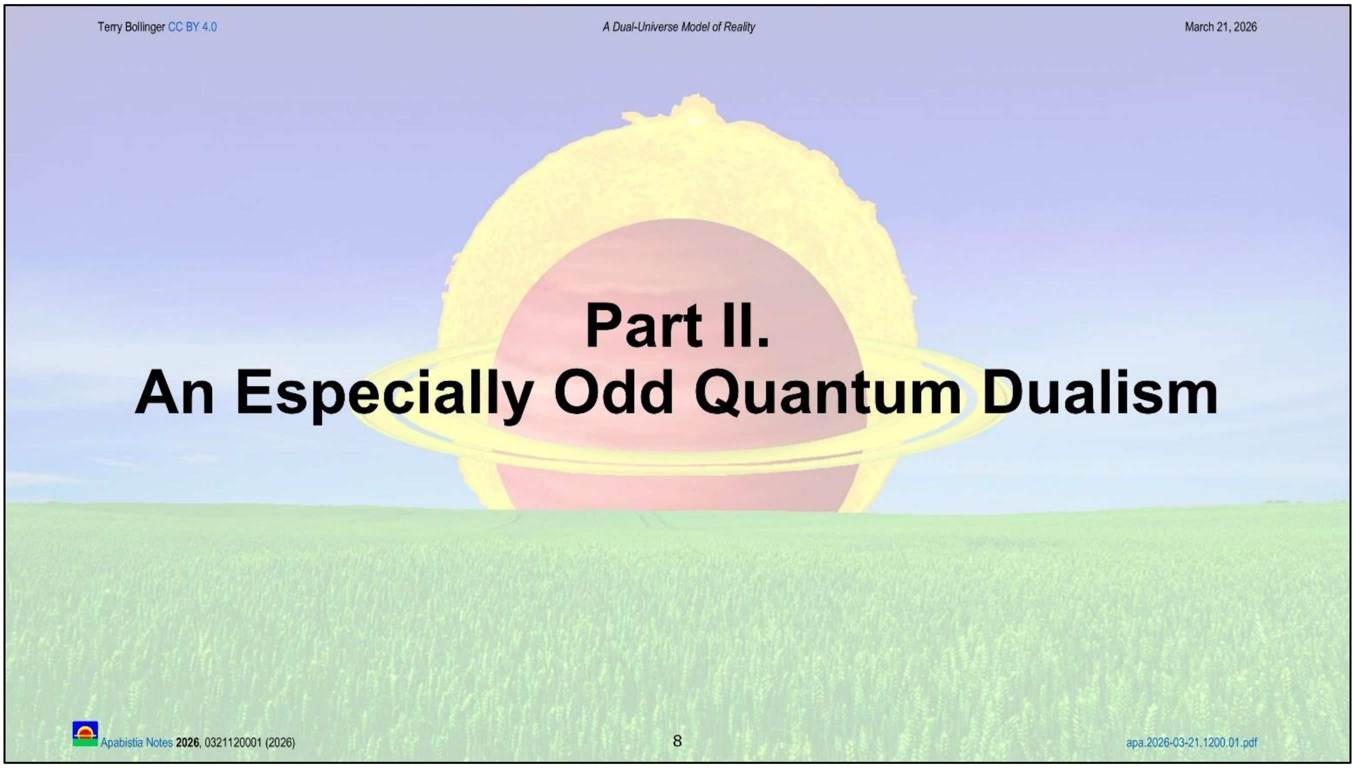
And that was not obvious. It was it was not obvious to either of them. It wasn't obvious to Schrödinger; it wasn't obvious to Born. But they both knew that both frameworks seemed to work.

I think Born was even more surprised, because he just kind of went [into it by trying to organize a bunch of small equations into a more regular table format.] And someone, I think, told him and said that, "Yeah… that's a matrix you're using there!" He says, "Oh, it *is*?" [So, Born] starts diving into that bit of mathematics, and then he finds out that it does a *really good job* of embedding these [quantum] concepts.

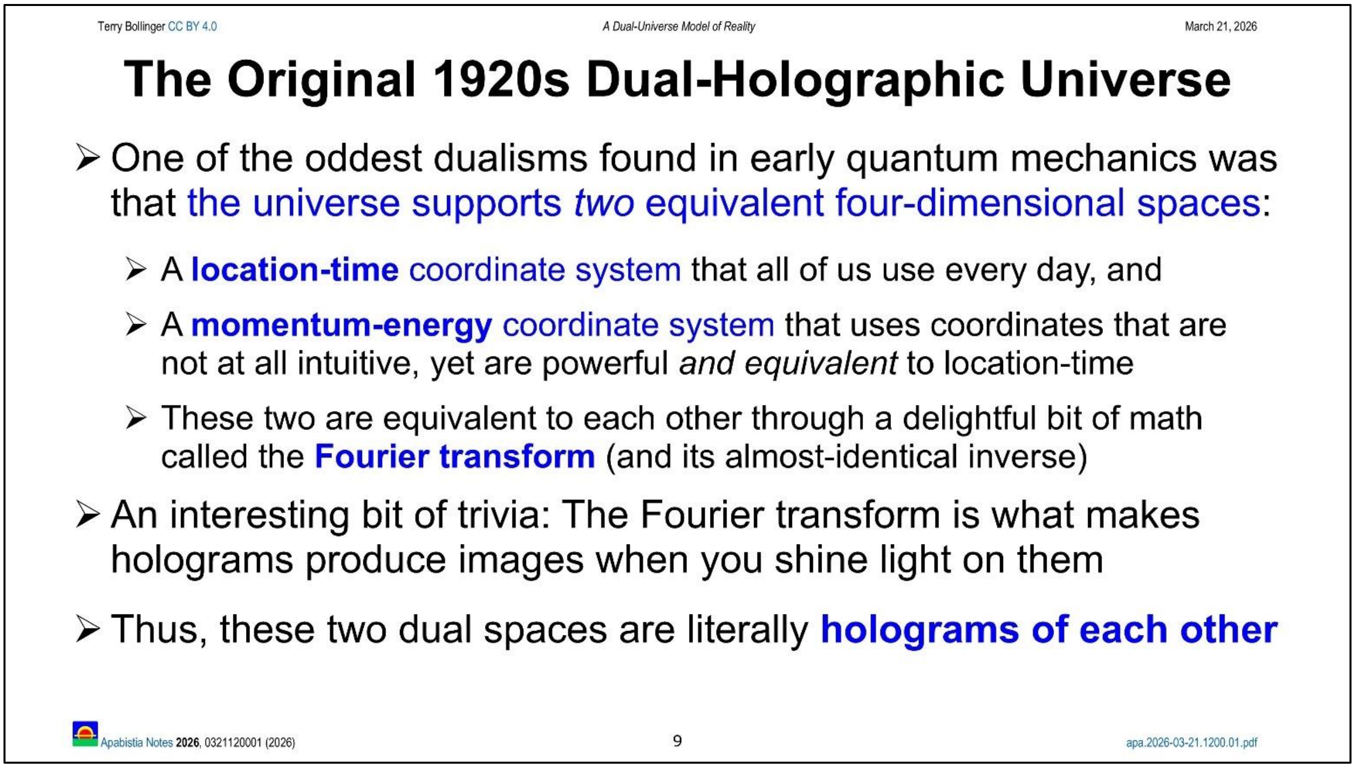
So, in *quantum mechanics*, you have a place where the *idea* of these dualisms — mathematical dualisms — comes out in a *very pointed fashion*. They're *not* always symmetrical. So, there are *different* forms of dualisms in quantum mechanics. In some cases, [the two parts] seem *identical*; in other cases, they seem very *broken*. So, you have a whole school of analysis in quantum mechanics — in particle physics — where you're looking at these different *ways* of interpreting the symmetries that go between these. And most of these symmetries are some form of dualism.

This has proven to be an *incredibly* powerful strategy for decades: The idea that if you can represent a situation in nature, and *provably show* that there's some kind of *mathematical form* [for it], and that mathematical form has an *equivalent* form. Often, you can get some *new* insights that you could not have gotten with *either one* by itself.

So, this is a *good approach* for getting interesting ideas — and also, some *very unexpected insights*, in many cases.




10:39 One of my favorite quantum dualisms is the one that's the most broken. It's so broken that many people don't necessarily describe it as a broken duality.




10:49 But I think you're missing something if you don't notice that there's something fascinating in terms of a dualistic symmetry going on here. And the point is very simple. And I'd be curious, ask yourself whether anyone has told you this before. I assure you it's true, it's not really even that radical, but it's not something that people emphasize. The universe is not one four-dimensional network. It is two four-dimensional networks. And the two four-dimensional coordinate systems have a relationship to each other that is very precisely defined.

*Although*, if you try to push it, and try to use one or the other, you can get in situations where it starts getting very difficult to describe what's going on the other side.

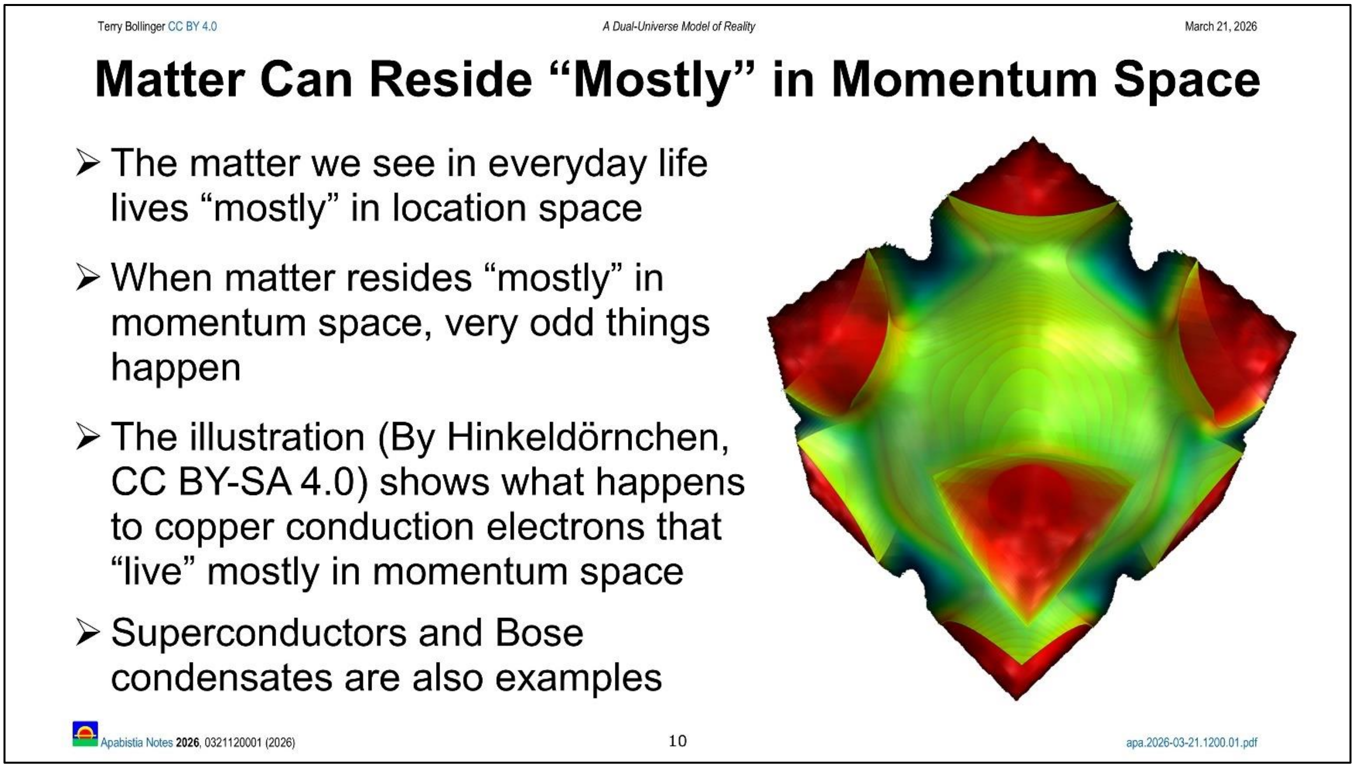
And this is the location time versus momentum energy coordinate systems.
So, everybody has an intuitive feel, we're built for it, our brain is literally, literally wired for it in fascinatingly complex ways. Our understanding of location is not trivial, and there's a lot of…
Neural architecture goes into that.
But we have this very intuitive idea that something… you have… something has a place in space.
And then it has a location and time, the time moves ahead.
That seems very intuitive.
Hmm.
The other system that is not intuitive.
It's when you take something that we think of as just as motion.
And as the total energy content of the system, and turn that into a coordinate system.

Even saying that, it's not terribly intuitive. You go like… and in fact, one of the points I would… as much as I've looked at this, the idea that energy is…
In some way, an equivalent to time, that there's a *symmetry* between time and energy, a trade-off between time and energy.
That's not obvious! (Chuckle.) I don't find that, you know, a straightforward concept — and yet, it's very much there. In fact, that particular symmetry between time and energy is one of the reasons why strange things like double-slit interference happen. It's why you have the anti-glare coatings on your glasses. All of these involve that very symmetry.

The math that goes between these two is a Fourier transform, and the inverse… the inverse, essentially, is the same thing, just from the other perspective.
The math is both ways. These are… these are wave equivalences.
If you have a regular frequency, like a radio wave.
You get, if you lock onto that frequency, it gives you a single point, say, I'm on such and such frequency. That's a Fourier transform! You do that in your radio all the time. So, you've seen Fourier transforms that you may not even realize were Fourier transforms. But anytime you say that I have a long wave, but it has a repeating character.
And then I can define that repeating character, and then I can define a number, a location, a fixed value.
then that gives you the other side of that duality. You give the transform. Now, what is…
I think it's just delightful.
is that these two have a relationship with each other that is very much like holography. Holography is where you, you know, you look at this sheet, and it has an image, pops out at you. We have them on our credit cards, pretty easy to find these days, but there was a time where it was extremely difficult to find good examples of holograms.
Well, these two spaces each contain the information of the other. They're separate representations. And then you go through this wave translation.
Well, that turns out to be about the same thing as holography. So, I always find it interesting when people talk about the modern concept of holographic universe.
We missed something really cool and really important, which is, that's not news.
They've had holographic interpretations of reality ever since they first came up with momentum space wave functions.
Because a momentum-space wavefunction is a hologram of the location-time wave function, *and vice-versa*. So it's like these two are sitting here having an image of each other, and kind of peering at each other.

But it's also a very broken symmetry, because time gives us the ability to have the universe moving forward [in time,] as we think of it. You don't see that with energy by itself. There's a break in that relationship. The entire idea of location in location space, it doesn't matter where you're at, there's no tremendous energy cost for being very far apart.
In momentum coordinate systems, it's just the opposite. If you have two points and you try to stretch them apart, like this momentum space.
It gets very high energy very quickly.
So you wind up breaking that. So… so the symmetry is… is seriously damaged in that sense, and yet also very cleanly defined in terms of the mathematics.

If you've never looked at Fourier transforms, it's something I always recommend. They're just a marvelous little piece of of mathematics, and tell us a lot about the world because of this relationship. Many of the strange things come from both this relationship and the *curious* way that it's broken.




16:06 An example of that break, if you see this little thing over here, that's a Fermi surface. This is what electrons look like

When you put them in a metal, in this case it was copper, I think is this particular example, you could do a sculpture show with these things. Each metal has its own set of surfaces where the electrons have an identical energy level.

And they look very strange, but…

I would even… I would even emphasize, they're even stranger than you thought they were. You hear about a momentum space, sometimes you may have heard it in terms of, like, a bow… if you've ever heard the phrase, a Bose…

Einstein condensate. That's… I love that term. Bose-Einstein condensate. It's where you've got some matter, usually electrons, sometimes hydrogen atoms, sometimes atoms.

More often atoms these days are getting better and better at it.

And you put them into what you call a condensate in momentum space, that same weird space he was talking about.

You can put matter into it. You can stuff things into it.

It's not always easy, in fact, usually it's pretty hard.

But you can do it, and when you do it, wow, things get weird.

So if you look at things like superconductors, those are Bose condensates. Those are electrons that have decided to say, yeah, I'm bored with all this space-time stuff. I don't like being locked down to a particular time, particular place. I'm going to delocalize, is the word that they often use with that.

Well, it's more than just delocalization. They're actually just kind of saying, hey.

I want to join the other side of the universe for a while. I'm going to stop with this, you know, okay, I don't want to be down, I don't want to be free, I want to be free. And that's what the electrons do.

So, an electron in a metal, one of the things that makes metals what they are, where they reflect light, where they have strength, where they carry current, is because the electrons in it do not behave like particles.

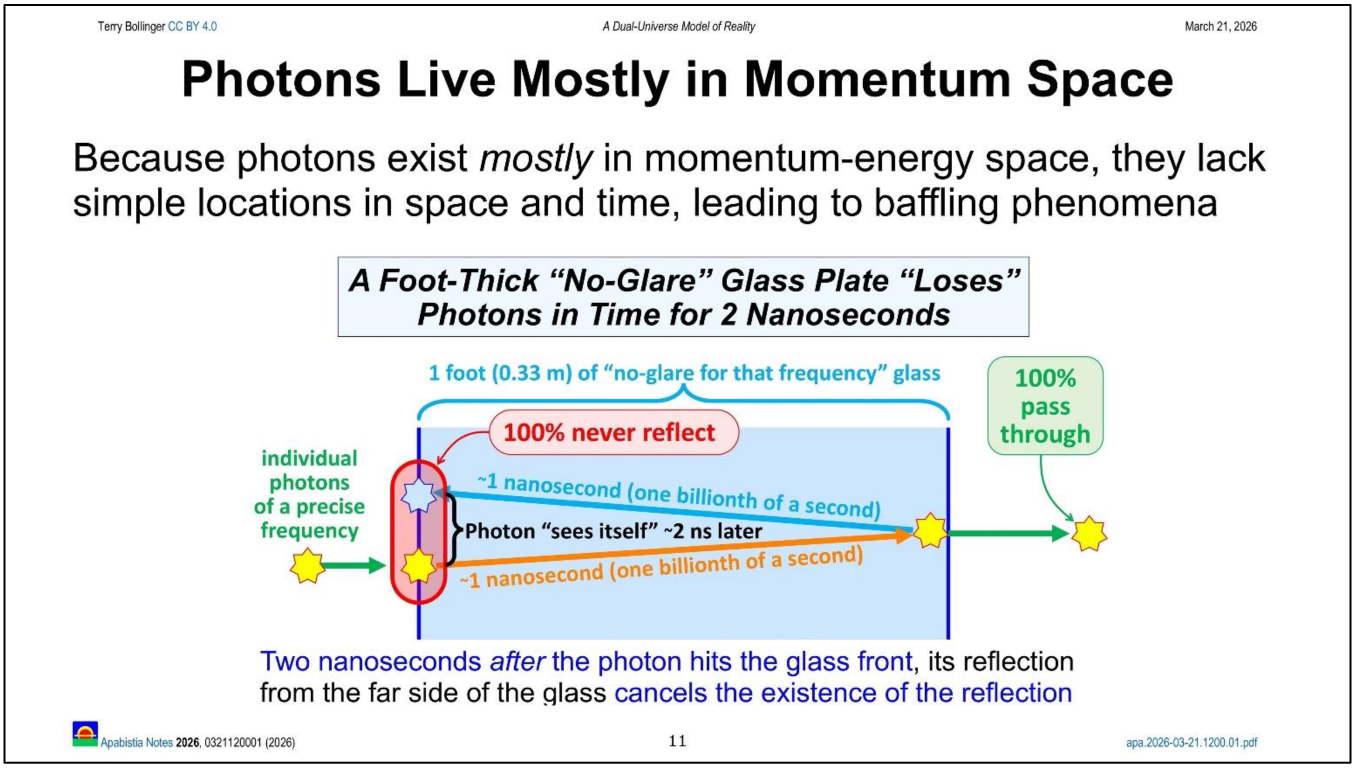
They behave like these wave functions that are cast over the entire system.

So it's a… and you won't get that when people emphasize the translation of those wave functions back into particles.

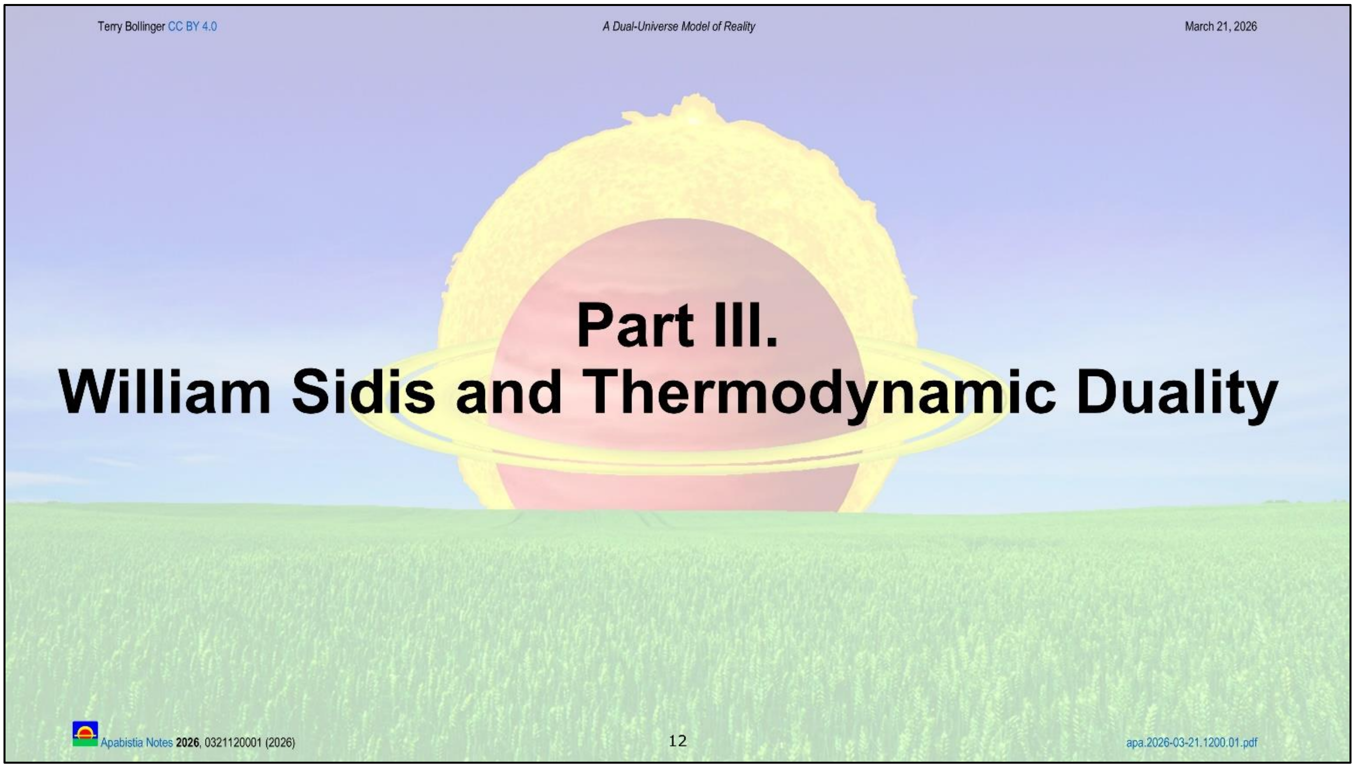
Because that kind of skips over that whole thing. Yes, you can always convert them back into a particle.

But you also are missing that some of the most interesting behaviors are because they weren't particles until you forced them to become particles.

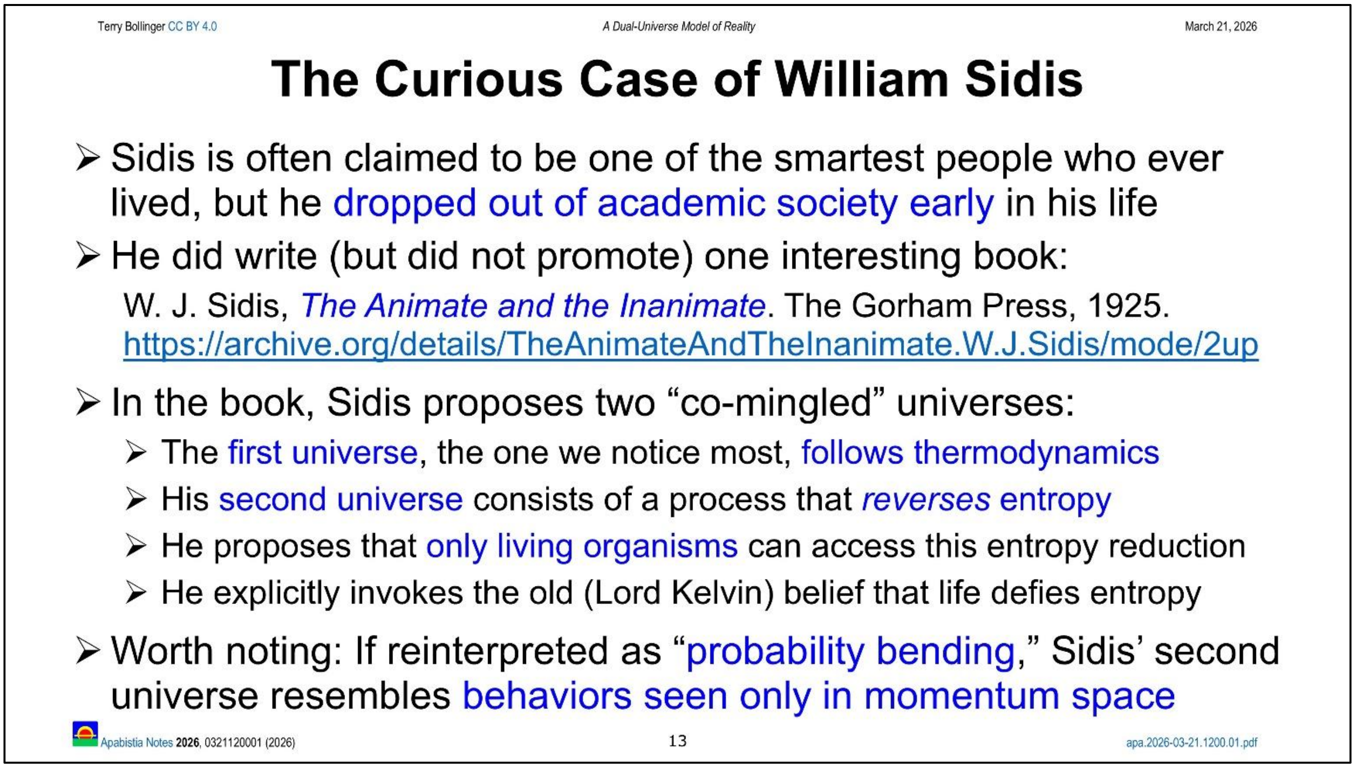
So, we have quantum mechanics. Every time you get a piece of wire, every time you have an electrical current, that is very intensely quantum mechanical. That is not something that happens in the classical world. We have these little images of electrons just going through the wire. It's never that simple.
And if you try to make it that simple, you lose a lot of the richness of this. So, matter can be in these spaces, so what does it look like when it's there? It's also…
interesting, because they're not even points. When you put an electron into one of these shells, like the structure that's showing up here.
The electron actually is a shell in that space, so if you look at the representation and say, how does this electron look in that momentous space? It's not a point anymore.
And this usually does get skipped. When people talk about a Bose-Einstein condensate, they treat it as if it's a little particle
you know, they call it a Fermi sea, and they just pile up on top of each other, just like a regular ocean. No! That is so not what is happening. They actually form shells, and the ones in the interior of the shells have the lowest energy.
Then you pile them on, and it just keeps getting thicker. Remember I said, farther apart, higher the energy. So they build up, build up, build up, build up, until you wind up with these incredibly high energy levels.
for the outermost electrons in those shells. How high is the energy level?
Well, someone's actually done some checks on this, because it's an interesting point. The metal silver, the electrons on the outside part of that shell.
which are actually… they are the outside shell, the outermost layer of that shell, have so much energy that they are in the X-ray domain.
And literally, if they all fell down back to the ground state.
And you were holding a piece of… you were near a piece of silver, it would kill you.
There's that much energy stored in the silver in the form of these piled-up shells in momentum space. There's no classical equivalent to that, and these shells look like this.
So, what I'm trying to suggest is that if you want to stretch your mind
And just realize that even everyday things maybe aren't as ordinary as you thought they were. This is a good place to look when you look into these… this whole idea of the simple… we use the term band. We talk about a band, electron band.
Electron band is one of these constructs. It's one of these layered constructs of all these different areas. So, fascinating area, well taken… well worth taking a look at if you want to stretch
Stretch your image of what the… what the world… universe looks like.
This is,
Again, my apologies, this is…




21:10 I was not coughing this badly yesterday, but I am today.
This is a slide from my last presentation, but it's worth pointing out because it deals with this whole issue of these different dual relationships.
You have this concept of a photon going through a large piece of glass.
And yet, if you set up the geometry right, it sees itself 2 nanoseconds after it entered the glass.
And because it can see itself 2 nanoseconds in the future, or in the past, whichever way you want to look at it.
It says, no, I'm not going to reflect. I'm going to go 100% through the glass and pretend that it's not there.
You only get this… When you go through this, Concept of the,
of a momentum space in which the idea of time has been converted into energy, and the energy says, I don't care, I'm worried about other things, I'm worried about frequency, I'm worried about interference.
And as long as you don't poke at that photon while it's doing this, if you look at the photon, it becomes a particle again. But if you don't look at the photon, if you don't force it back into ordinary coordinate space.
Then it does its own little thing in this very strange space in which it's looking at time from a very loose kind of a perspective.
Many of the things that you do with light are for just that reason. And again, each of these activities, as Feynman's QED pointed out very well.
is one photon. This is not a wave, this is not a herd of, you know, a gazillion photons doing this so they all interfere with each other, no.
One photon does exactly this.
And then you sum them all together, and a whole bunch of photons give you the effect of a wave, but the wave was there already. The wave was there in a single photon that was trying to do issues like this. And it makes use of this marvelous little duality between momentum space and location space.

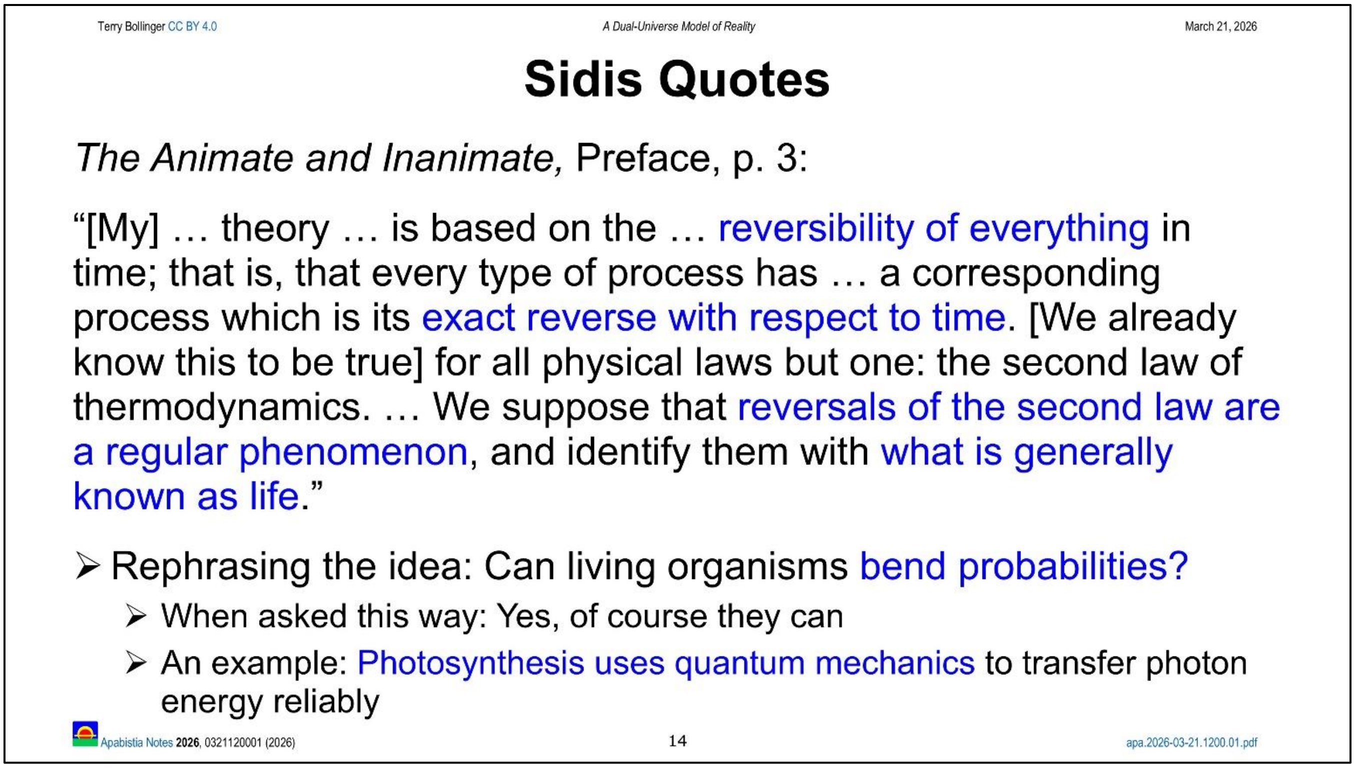



23:13 Which will bring me on to a broken duality. And again, this is just a fascinating fellow. And I… I would feel guilty if I didn't mention him when I talk about duality in terms of physics, because he certainly took a look at this from a perspective that is different from most.

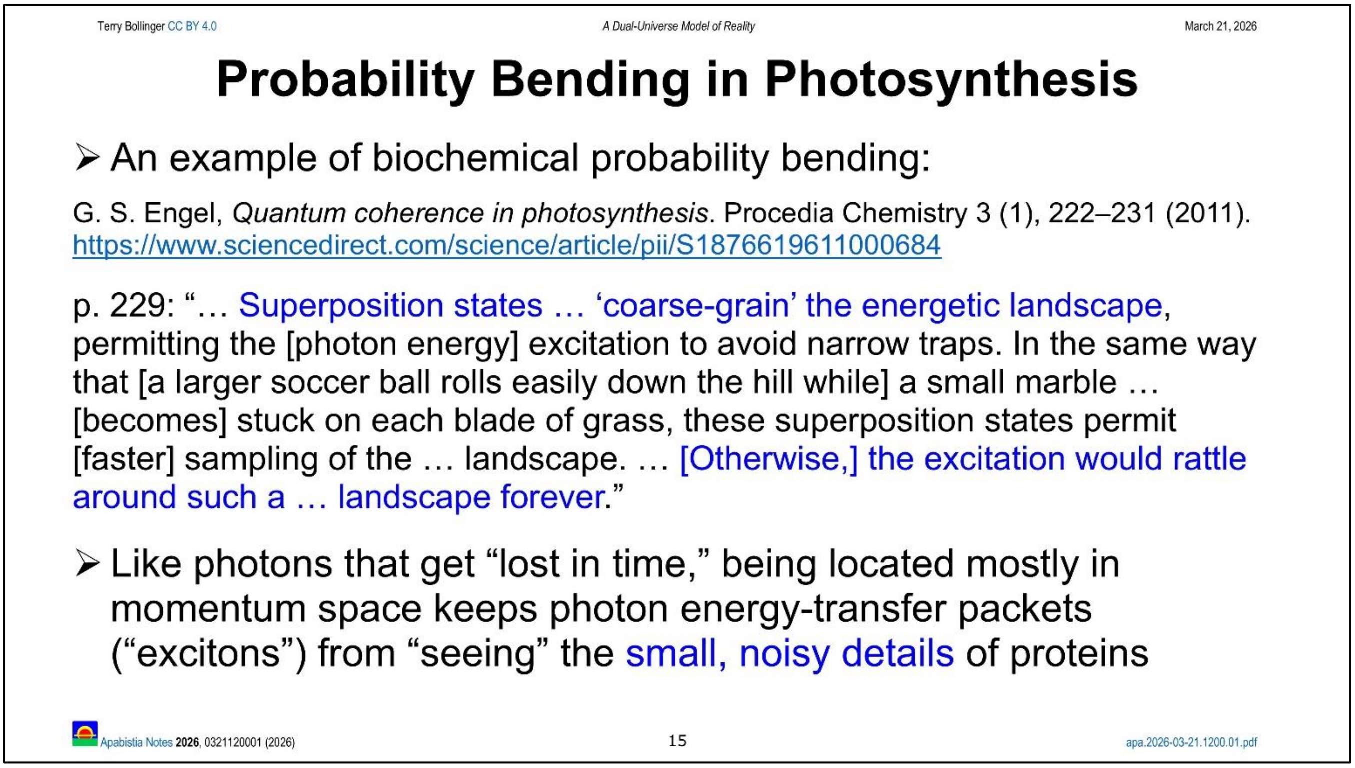



23:35 So, you may have heard of William Sidis, and I'm probably saying his name wrong, I think it's actually Sidus. But, William Situs.
He, for various reasons, has been promoted as being one of the smartest, or the smartest person, depending on who you're talking to. He was a very smart fellow.
But it… things did not work out well for him. He wound up just kind of mostly dropping out of society, certainly the science side, but also just in general.
And, so the hopes that people had for them never really,
added up that much, which is unfortunate, because he was a very good thinker. But he did write an interesting little book.
And it's easy to… it's easy to find it on the internet.
And, it's an interesting read. Now, his book, the thing I should point out is he… what he's really doing is he's going back in time to a different
Philosophical Perspective, which is the one that you've heard about the life
Now, scientists is careful not to phrase it this way, but he's talking about Lord Kelvin, it's where he got the idea.
And Lord Kelvin was one of the many people of his time that had this idea that life had a special force, a special something or other, that allows it to do things.
That is not a popular view for some very good reasons, because it still is subject to all of the rules at the atomic and molecular level of thermodynamics. We still see the same thing, so people tend to emphasize, say, yeah, no, it's just that this is clever machinery.
And that gives you a better, more encompassing envelope. But Sidus was trying to point out and say that, yeah, that's true.
But if you look at what life does, as Lord Kelvin also said.
It's… it's just defined the application of entropy, and the universe seems to be this weird mix of things that just continue to kind of, you know, scatter and break and go down to smaller, smaller pieces.
And at the overall energy level, that's irreversible.
But within that, you have these interesting little pockets where something called living organisms are very good at restructuring things.
So instead of dying, it heals. Instead of disappearing, it gets more complex.

So, he looked at this and wanted to interpret this in terms of a concept of physics, that there's a second universe, a dual universe.
That has its ability to reverse entropy. Everything else, the laws of physics, are trivially reversible between past and future, except for entropy.
And he proposed that there's a subset of active… of behaviors
That certain types of material systems, they're still material systems, but they can access this reverse on that.
Now, one of the reasons why I took the trouble to mention Citus is I do want to point out that the asymmetry he's talking about is very similar to the asymmetry that we see between location space and momentum space.
Momentum space is capable of doing things that don't make sense, that bend the probabilities that result in outcomes that shouldn't have happened.
by any kind of classical analysis. One of the examples
And I think,
This comes up in one of the later slides, but one of the examples is, if photons were truly just particles.
We would not be having this conversation.
If that's all they were, if they were just particles, we wouldn't be having this conversation. Why? Because every photon would get lost when it goes through the lens of your eye.
It would just bounce around there like a pinball, and we just have no idea where to go.
Photons cannot get through a complicated Protein-filled, molecular.
kind of weird thing that we have that we call the lens.
Unless they were able to just kind of smoosh right over a lot of those details and say, I didn't see that.
I don't care. I don't, you know… I know you're wanting me to go down this little pathway. I'm… I just don't see it.
And the way they do that is by hiding in momentum space. Photons are very good at hiding momentum space, so they'll follow to a certain degree and say, oh yeah, you want me to go that way, but you know what? I'm… I'm gonna look at it a little bit more fuzzy, because I have very low energy, so I don't have
You have this relationship with time going on that allows it to blur things. So,
when Sidus is talking about this, every time I've read through his stuff, I go like.
I wonder, and I wish he had known more about the mathematical precise forms of momentum space, because I think he might have had an interesting
Take on that. But again, he started off, it was in the 1920s.
And it just, never went anywhere, so I didn't get a chance to explore that, but it would have been very interesting.




28:43 The book is called The Animate and Inanimate.
And he says that, this process that living organisms can do.
Is reversed entropy with respect to time.
He doesn't address real well the idea about, you know, just being fed by energy. We would say that energy, as long as you have an energy feed, you can locally violate
the entropy, rule. That is, you can make something locally become more complex, but you still have that energy cost.
And he gets into a little bit like that, but Cytusk doesn't go in great detail. He was more interested in saying that something really interesting is going on here, which seems to be at the physics level.
That is, it's not just… it's not as simple as just saying, there is
machinery. He's saying that, yeah, it's machinery, though, that does something
That we don't understand. This is an idea that's also becoming more relevant with what we're calling artificial intelligence, which is purely mechanical and has a great propensity towards entropic decay.
So, can living organisms bend probabilities? Yes, of course they can. Every time you have an enzyme, you're bending probabilities. You're going from, like, a very low probability to a high probability. Can you explain that purely in terms of mechanical
Types of systems that you can emulate that with just, you know, literal balls and mechanisms and levers.
That gets a little dicier, because what we see when we look closely, is that mechanisms, for instance, a good example is photosynthesis. It has to have quantum mechanics
to do its transfer. So it's not as simple as saying that, oh yeah, you know, it's just a machine. Well, it's a machine, but it's a machine that's using quantum mechanics, and that automatically puts it into a machine that's accessing these two different
universes, the location universe and momentum universe. The momentum universe gives it additional properties that you can't access otherwise.




30:47 There are a number of papers on this topic. This one is a nice one by G.S. Engel.
People found out… Back in the…
Back a few years ago, they found out that photons were doing this marvelous little trick where they have, with almost 100% reliability, a transfer of the energy from a photon across some interesting barriers inside of the photo complex.
And, this is complicated.
You know, so if life is bending probabilities, it's not by some, you know, weird little waving of a magical wand. This is highly structured stuff.
And the machinery inside of these photosynthesis complexes is able to convert the likelihood that that energy would just dissipate and go poof, and then, you know, no photosynthesis.
And then convert it to, a direct
Pathway in which it goes, to these… this other site where you want it to convert it, eventually into sugar, into other… other forms of energy storage.
So, this particular author compares it to the difference… this same analogy I just used, by the way.
The difference between The exciton, which is an energy particle, quasi-particle.
it gets stuck. If it was an actual particle, it wouldn't be able to make it. It would just… it would just stuck, say, okay, I'm gonna whack this protein, everything blows up and just dissipates.
Instead, it's able to kind of fuzz that image out.
Go through a bunch of fibers, and ultimately wind up going right back to the location it was, without getting lost in all those little details.
So, being non-particle, like having essentially bloated in both space and time, because there's always a time aspect, it's not just space, so these particles, that they have a size that is well outside of the idea of a point, is critical for this… this to be able… to be able to
It's critical to get this to work.
And, life makes good use of it. They make better… one living cell makes better use of this mechanism than we do in a lot of our giant quantum systems that we try to build.
It's more efficient at it, it's better at getting,
Room temperature, quantum mechanics, because all of this is going on at room temperature. This is not some super cold thing, this is photosynthesis.

So, these systems that you see in cells, these biochemical systems.
They're good at this, but it's not by accident. It's because they have some nice structure to them.

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## Nobel Laureate Hopfield on Probability Bending

J. J. Hopfield, *Electron Transfer Between Biological Molecules by Thermally Activated Tunneling*. Proceedings of the National Academy of Sciences 71 (9), 3640–3644 [Sep.] (1974). https://www.pnas.org/doi/abs/10.1073/pnas.71.9.3640

> p. 3640: "The overall effectiveness of … photosynthesis … depends both on there being a large electron transfer rate for desired transfers, and a small rate for inappropriate transfers. … The simplest … coupling of electronic states to molecular thermal motions … to calculate the temperature-dependent electron transfer rate … involves tunneling. [p. 3644] … The tunneling matrix element is generally not appreciably temperature dependent."

J. J. Hopfield, *Kinetic Proofreading: A New Mechanism for Reducing Errors in Biosynthetic Processes Requiring High Specificity*. Proceedings of the National Academy of Sciences, 71 (10), 4135–4139 [Oct.] (1974). https://www.pnas.org/doi/abs/10.1073/pnas.71.10.4135

> Abstract, p. 4135: "The specificity with which the genetic code is read in protein synthesis … can be increased … by a process defined here as kinetic proofreading. … Known reactions which … appear … useless or deleterious … are … essential to the proofreading function."

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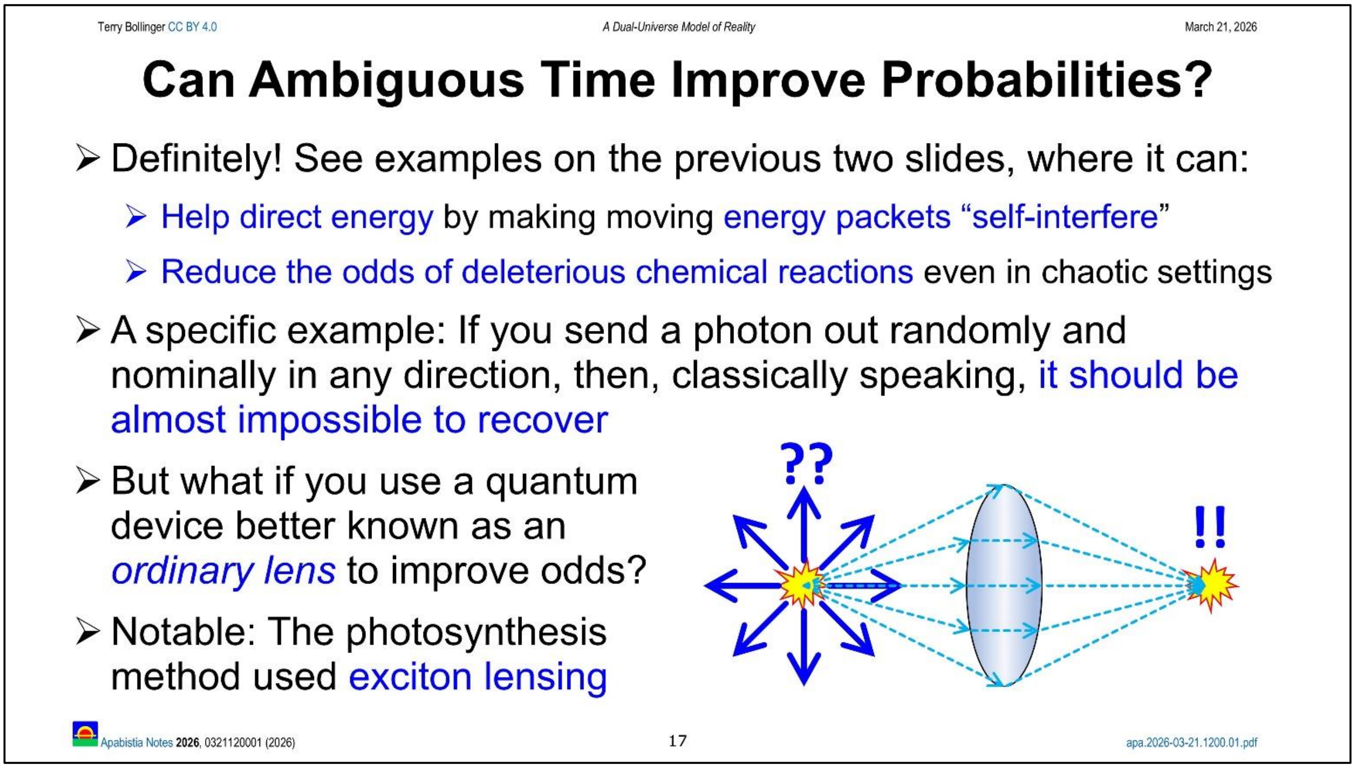
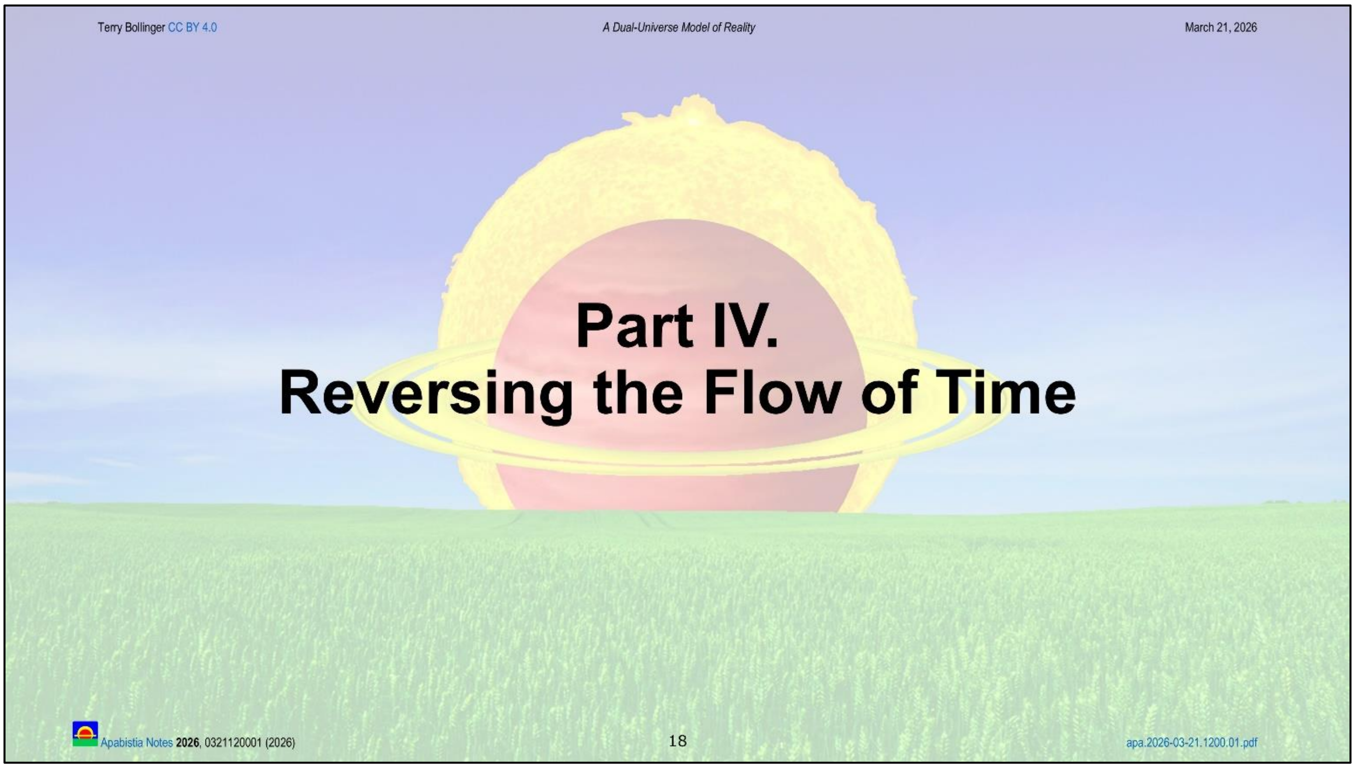
33:34 A recent Nobel laureate.
One of my… one of my comments I've said a couple times is that I wish they had given him the Nobel Prize for these two papers, as opposed to the paper that they actually gave it to him, primarily for. And the reason is that on these two papers, he was getting at this issue.
He was really saying, like, oh, yeah, there's something…
really intriguing about how we get the photosynthesis, the same thing that the other authors were addressing. He's one of the earliest people to address that, back in 1974.
But he also pointed out that there's an even more complicated mechanism going on in protein synthesis. And that one's… that was interesting, because if, you know, if we're trying to build
A machine to process chemicals.
The way we do it is we build this really rigid tube, we make sure the tube contains everything, we make sure there's no chance it's gonna leak.
We make sure it goes here, and you want the chemical engineering people to do this, you don't want this stuff leaking all over the place. So, you'd look at it, you might say, like, well, I guess life probably does the same thing when it's taking amino acids and putting into proteins.
No, not at all. It's kind of the other way around. It's chaos. It's got this weird, chaotic environment. You have, as he says, useless or deleterious.
Chemicals in that environment turn out to be essential to the proofreading, to making sure that the code worked right, to make sure that you actually produce a working protein.
We don't know how to do that. We can see it, we can watch it, we observe that it's happening, but if we try to build a machine that does this.
We can't access that quantum part, at least not with systems that we're able to build, unless we just replicate exactly what those are, then we can always do that. But to actually build these? We're not good at that.

And we don’t understand how this works. I truly wish Hotfield had put in more work in this thing, because I think, especially back in the proofreading, I think that is just some very interesting physics going on here. Something that might have made Citus happen if he had lived and, you know, stayed active longer.




35:48 Now, here’s a simple example, but I want to point it out, because
One of the things about classical physics is that we’re so used to it that we don’t realize when we’re actually talking about quantum physics.
And I gave that as an example of metal. When you look in a mirror and see a reflection, that’s not classical physics. That is so quantum, it’s hard to express how quantum that is.
Because the electrons that are bouncing that image right back at you in a smooth, current fashion
are in the X-ray range, in terms of their energy.
They can only be in the X-ray range because they have this pile of shells that don’t even look like particles over in momentum space representation.
What looks like a simple action, once we get out of the habit of just accepting it as a given.
turns out to be extremely complicated and extremely quantum. Well, guess what?
Lenses are another example. If a photon, and this is really just… this diagram’s just really restating the same thing I’ve said a couple times. If a photon just went out as a particle, you see the blue lines on the left.
And just shot out. Photons move so fast, that photon would be gone forever. Your chances of finding it would be so close to zero that just… there’s no hope. So I say, well, okay, so my probability is zero. Is there any way I can fix that?
Well, yes, there is, and that’s what’s remarkable. We call it a lens.
If a lens takes all of the… a big chunk of those probabilities.
and goes… plays certain magic again. This is machinery. This is… this is… it’s not magic in the sense that it just does it, but if you have a very precise design to it, which is what the cells do at a level that we… we don’t understand.
then it’s able to redirect the probabilities and say to that one single particle that says, yeah, I know you’re lost, I know you’re out, who knows where.
But, you know, I’m gonna force all those possible ways that you could have been to converge onto one point, and you can wind up getting an extremely high probability

that the photon winds up right here at the focal point. This is what our eyes do all the time.
This is also what's going on in the photosynthesis. That is a more complex form of lensing of a particle that we don't think of
Very often, it's called an exciton, an energy excitation.
But you still see the same effect. So ordinary lensing, which we tend to think of as a trivial issue.
is actually a bending of quantum mechanics, and seems to be very much a mechanism that's in use when you look at the… at how life works. So, fascinating little thing that we can… can even do that.
Photons, because they live mostly in momentum space.
are agreeable to this. They say, like, yeah, okay, okay, I don't know where I'm at, I have no idea where I'm in your domain, but if you want to put one of these devices.
Alright, I'm with you, I'm with you, I can do it.




38:44 Now… I'm gonna get into a different duality, still related.
But that is reversing the flow of time.

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# Dirac Predicts The Backward-Moving Positron

P. A. M. Dirac, *A Theory of Electrons and Protons*. Proceedings of the Royal Society of London. Series A, Containing papers of a mathematical and physical character **126** (801), 360–365 (1930). https://royalsocietypublishing.org/doi/pdf/10.1098/rspa.1930.0013

p. 361: "Let us examine [a] negative energy [electron state] more closely. … [Its] trajectory [in a given electromagnetic field will be the same as] … an ordinary electron with [charge -e and] positive energy. [However, it will] move in [a] reversed [direction within that trajectory]. [Notice, though, that this reversed movement is equivalent to a new kind of] electron of charge +e and positive energy moving in the [same reversed direction in the] electromagnetic field. Thus, an electron with negative energy moves in an external field as though it carries a positive charge."

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38:53 This is where you get to the part… this is where I'm starting again more directly into this idea of not just Dual intermixed universes, that's one… that's one concept, that's one I've been talking about mostly so far, is the idea you have a duality that's absolutely there right now in our universe.
That has two different ways of looking at universe, which are equivalent and yet severely broken.
But you also have, starting in particular with… it wasn't just Dirac, but I am going to poke at Dirac, because…
What a mind. Dirac is just… I… Dirac is just… I don't know. He just… you read his stuff, you're like, what was he thinking? You know, it's strange stuff. Feynman loved Dirac. Feynman loved Dirac. Dirac didn't seem to love Feynman much, but… but, I mean, he loved Dirac's work.
And went to great trouble to find copies of his papers, because Dirac had this just unique way of looking at things.
And Dirac came up with this point when he was…
playing around with his matrices. He didn't even know they were matrices at the time. He thought they were versions of, essentially complex num… more elaborate versions of complex numbers.
A little bit akin to what we would call quaternions or hypercomplex numbers, but he was playing with that, and he didn't even know what he was doing. He was just saying, this needs to be linear, this needs to work. He spent months on it.
just kind of poking around on it and saying, how can I get a mathematical representation that works? And when he got that representation, a matrix representation.
He noticed that something was pretty wonky about it. It would give this idea of an electron packet, the idea of a compact wave function that approximates a particle.
could have two solutions. One of the solutions was just an ordinary electron, it goes forward in time.
But he had this other way that said that if I took that same wave function that I just identified, and I have an electromagnetic gradient, so I have some kind of a complicated field here.
And, I put that thing into it, it would move in the opposite direction.
So, he was looking at it, saying, like.
If it moves in the opposite direction, that would reverse the energy issue.
And suddenly, I've got a real particle with positive energy.
And this is called, now, the positron. By the way, he did not know that. He was… he tried very, very hard to make it into a proton.

You know, and you see this over and over again in the early science of these things. We have two main particles that make up everything that we can see, like, you know, the neutrons were a separate issue that came up later.
But you see these protons, you see these electrons, so they… people wanted to make that into a broken symmetry. They wanted to make that into that. So he immediately leapt to the idea.
that the proton was this particle, that this wave function was that. Well, that proved not to be true.
But what turned out was true was he had predicted the first example of antimatter.
And the way he predicted it was that he has it going backwards in time. Now, I… there's a little nuance here. Anytime you play with these time reversal symmetries.
Oh, is it easy to get things messed up. It really is, because our minds just don't work that way. You know, we say and talk about seeing a film going in reverse. Yeah, but we're seeing that film going in reverse in positive time, so you've actually introduced some conversions before you even make that statement. So you have to be very careful how you state these symmetries in this. But he made the point, and I think it's a good point, that when this thing goes backwards in time, it has positive energy.
So it's really not, you know, it is part of our universe, it has positive energy, just like the regular electron, but it has an opposite charge.
So, he found this symmetry, he didn't know quite what to make of it, he misunderstood a little bit, but it was a great prediction. This is a mathematical prediction. This is… this is where I love good math. He was doing the math, he worked hard on it.
And he comes up with this prediction that he didn't expect.
But he knew that the math was accurately mapping what he was trying to do. He also had inspiration. Dirac always had inspiration.
It was hard to figure out where he got his inspiration sometime, but he, you know, he also had this idea of linearity was extremely important. Why did he think that? He just did. It's hard to understand sometimes how he thought about things.
But, he came with his prediction.



# Wheeler Takes Reversed Time Farther

At his Nobel Prize Lecture, Richard Feynman recalled how, in the Spring of 1940, John Wheeler called him with a truly wild idea:

> I received a telephone call one day at the graduate college at Princeton from Professor Wheeler, in which he said, "Feynman, I know why all electrons have the same charge and the same mass" "Why?" "Because, they are all the same electron!" (...) I did not take the idea that all the electrons were the same one from [Wheeler] as seriously as I took the observation that positrons could simply be represented as electrons going from the future to the past in a back section of their world lines. That, I stole![2]

- Wheeler had Dirac's positron idea to a whole new level, postulating an entirely new antimatter universe residing "somewhere" in ours
- This idea was very much testable, but proved not to be true



43:20 So that's the first idea of this…

particle that's, in some sense, going backwards in time, and you got these symmetries. You've got the space, you've got the time, so he kind of kicked off… kicked off that idea, and some other folks went wild with it. In particular, John Wheeler.

The most interesting physicist of the late 19… of the mid-1900s was Wheeler slash Feynman. When you got those two together, they… they were fun. They… they… they… Wheeler was the wild idea guy. Feynman was a conservative guy. He's the guy that said, let's make this work. I want to just do it like that.

So, they would, he got a phone call, I know this story. He got a phone call from Wheeler one day, he said, Richard! Richard! I don't know if he called him Feynman or whatever, he said.

Fine a minute, I know why electrons all have the same charge. I understand it now, why they all have the same mass, and find me…

I could almost see it in front of his face, say, okay, yes, what is it this time? Because he knew that Wheeler could go off on some interesting tangents, and was also a very good physicist.

So he said, because they're the same electron! It's just one electron, and what's happening is, it's going forward, and backward, and forward, and backward, and it's just the same… it's multiprocessing, you know? So, you get this impression that Feynman just sort of said.

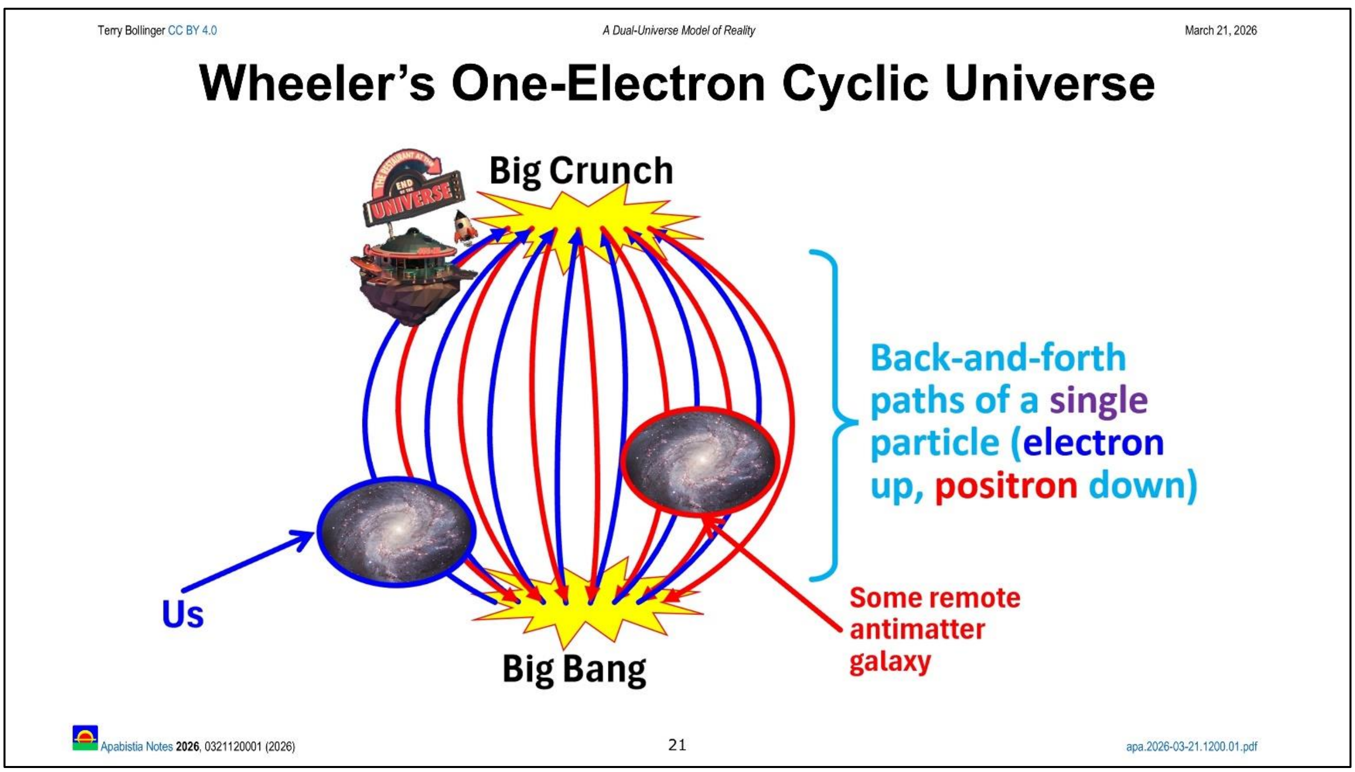
Oh, okay, okay, John, we got it there. But he also says it got him to thinking.

You know, and as he stole… as he tells in the Nobel Laureate story, he stole the idea, but he made it more, shall we say, practical. He said he didn't try to put it in that whole
universe level. They say that, yeah, there's something interesting about the idea of going backwards in time. So you see this backwards in time duality starting to pop up.

And it was good for Feynman. It got him a Nobel Prize. This quote is from his Nobel laureate lecture.

So, they had taken the idea of duality of time.

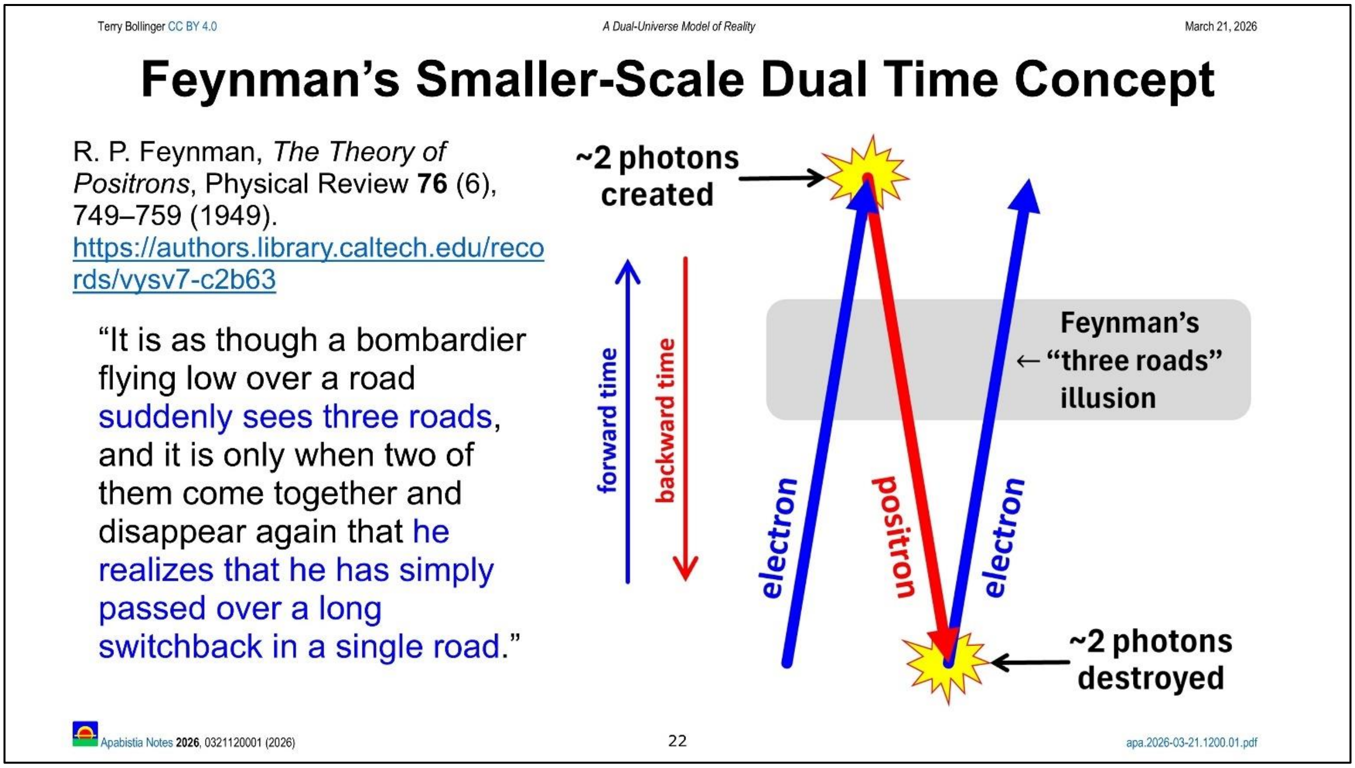
Wheeler had taken it to a whole new level.




45:32 Now, what… What Wheeler thought was going on is this.

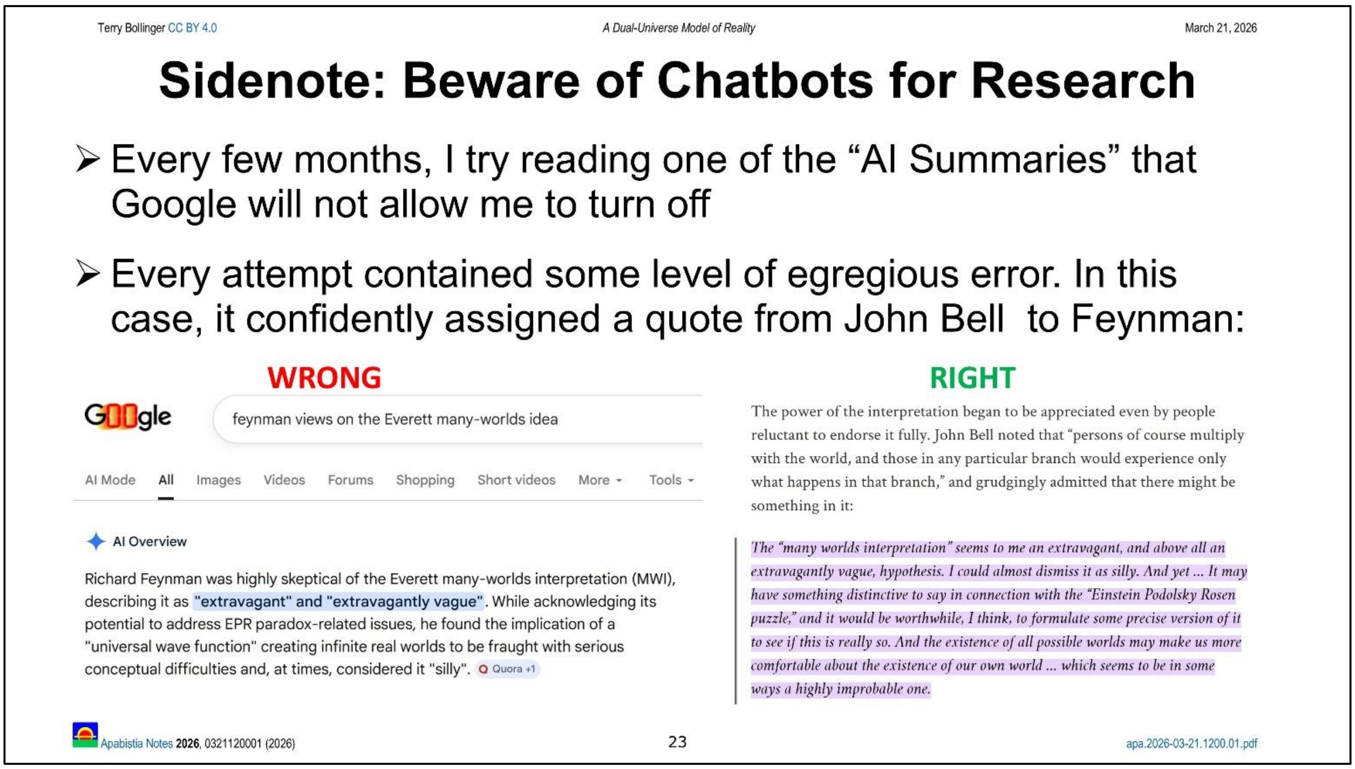
There was a theory at that time that the universe had two events, that it was cyclic.
that you had the Big Bang, but then everything would go back together, and you have a big crunch, and the Big Crunch would then turn into another Big Bang, so just…

Back and forth.
This is famously documented in the second of the Hitchhiker's Guide to the Universe books.
By the restaurant at the end of the universe. The idea is that you travel forward in time.
And there's this restaurant where you can watch the universe collapsing in on itself. Very cool. And it would be, I mean, if you could survive that.
So, literally, he used that physics idea, the same one that Wheeler had used, to come up with this idea for the Hitchhiker's Guide, which is one of the reasons why that's such a delightful bit of science fiction. He played with some real ideas in physics and did a good job of it.
So what's wrong with this idea? I can remember when people were trying to verify this idea. People were looking hard to see
if the predictable consequence of this was in existence. And that consequence is this, that you had to have galaxies, an equal number of galaxies, made out of antimatter.
So you had the matter galaxies, which we're in, but you'd have to have antimatter galaxies.
which were taking those same electrons back in time. You can't just mix them willy-nilly. You have to have some kind of spatial separation, because, of course, matter and antimatter, when they go together, bad things happen. So, this was a very specific prediction, and there was quite a bit of work done at the time.
to look for the possibility of these galaxies. The net result? No, there was nothing.
It would have produced levels of radiation that would have been trivially detectable, even if we had the astronomical separations.
The current string-like vortex constructs of the galaxy, the universe that we now know exist.
just absolutely could not tolerate something like this. There's no way, because they actually funnel meta… they're like matter tornadoes. You see these long filaments that they show you? Those things are twirling.
They're twirling the entire galaxies, and they're just kind of, you know, swinging them around. So there's no room for this idea. But it was just such a marvelous idea. And Wheeler was getting, at an important point.
Which is this, why are all the electrons exactly the same? If you just made copies of them, the copies should mutate, they should change, they should be a little different sometimes. That's never what we see.
Practical physics is unbelievably well
united across the universe. And this is what Wheeler was getting at, really, is saying that there's some kind of deeper reality to all those particles.



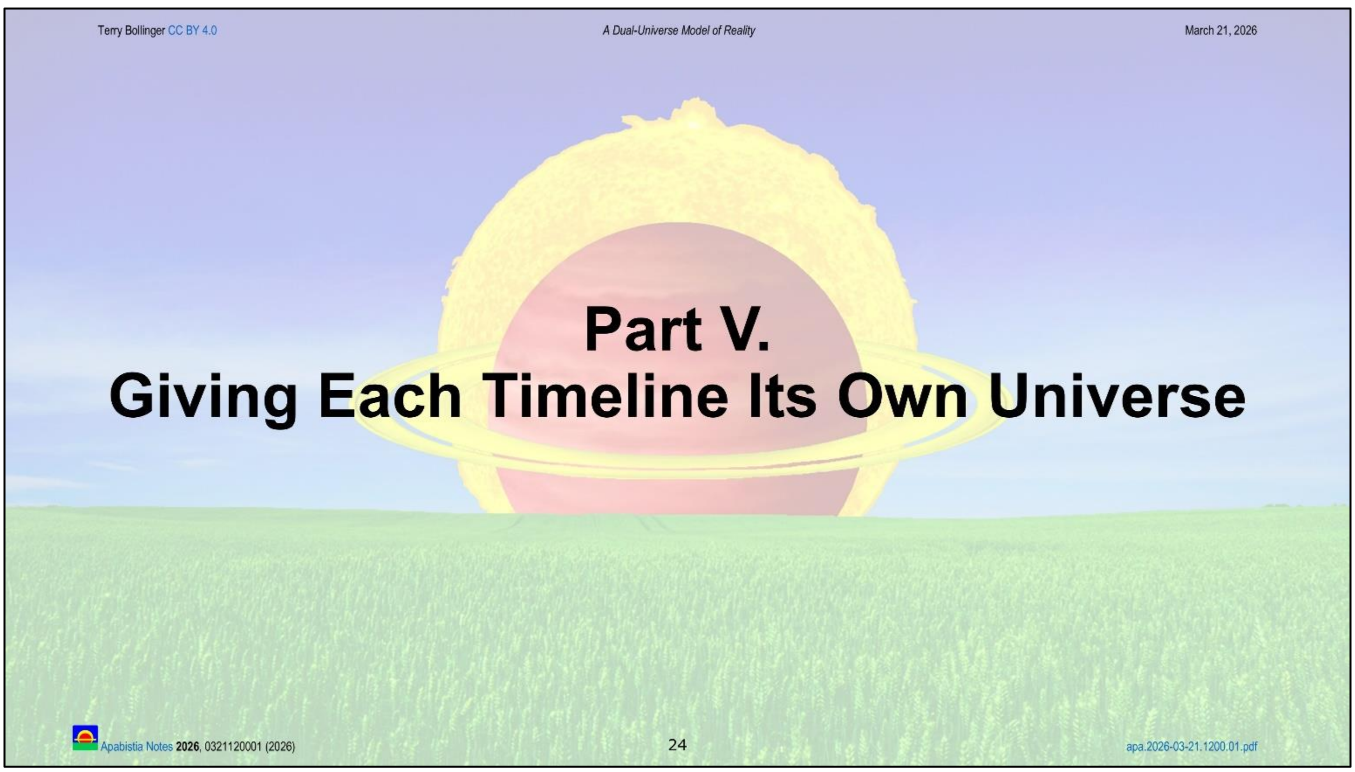

48:19 So, Feynman scaled this idea back.
He still liked it, but he said, you know, okay, I want to do something. I can't do anything with that. I want to do something with this. And what he did with it was he came up with this idea that
What happens if I just do this over a short rage?
And I have these events in which, you know, photons can get destroyed. By the way, two photons can annihilate each other and produce an electron and positron. It's not a common reaction, but you can actually directly take two photons
and produce an electron-positron pair. That's the lesser-known time inverse of the usual process.
And it's usually… it can be two photons. If you've got matter involved, it can be something else. If it's only photons, then it has to be exactly two. But if you have some matter hanging around an atom or something, you can get much more complicated in how the photons work.
And then there's the other event, is that the two photons get
create… or the two photons get created when the electron polytry and collect. This is the… this is the big boom. This is when electron… when matter meets antimatter, they come together and boom!
But Feynman had this… in his paper, he describes this very, you know, openly. The quote's on the left.
And it was a wartime era, so he used a wartime bombardier flying low. But he said that you could see, three roads. They said, oh, there's three roads down there. But then, as you step back and look at the bigger picture, you say, no, actually, there's only one road.
But it does a switchback. It goes back and goes up this way, then it comes back this way, and goes out this way.
And it actually reflects, and uses that kind of terminology, it actually reflects off these explosions. So the electron goes up here and goes, oh, bang, okay, I don't want to go that way, so I'll go back this way for a while.
And you go, bang, oh, okay, now I'm gonna go the other way for a while.
Because from its perspective, that's also a bank. So, he just comes with this extremely visual, idea, taking… taking Wheeler's idea.
And saying, we can look at this and realize that an electron may go forward or backward in time. Same electron. And we just interpret that differently.
So, I remember I was in a bookstore once, and I was talking about, to someone there that worked at the bookstore, about, about Feynman, some of his ideas.

And I… I mentioned this one, and we… we've been having a good conversation, and then I'm missing this one. I said, wow, you have noticed about the electron going backwards in time. And I could just see it on their face, they go like, oh, okay, this is cra… this is Tim Hat stuff. And, I was so am…
I was a little chagrined, but I also was so amused, because I, you know, I wanted to say, this is what he got his Nobel Prize for, you know, so I'm not just talking here. He got a Nobel Prize for this idea, but the idea was so,
So wild-sounding. If you stayed as bluntly as Feynman did, that, yeah, it sounds a little crazy, like the idea of bouncing off of an explosion in the future and coming back, going backwards in time.
And some good science fiction has used that idea for actual versions of time travel. They've essentially done just this, with entire
you know, beings and spaceships, and not just individual particles. Feynman… why did Feynman do this? Because it gave him an ability to mathematically quantify and predict
How electrons, positrons, and photons behave.
And if he had not done that, he would not have gotten the level of precision that he did.
So, no matter how strange this idea sounds, the idea of electrons going backwards in time
Is real enough that it aids in calculation.
And that's always one of your tasks. If the idea leads to precise calculation, that's where the math really kicks in. Math can give you insights, but math also should give you calculations. So the math gives you… gives you good calculations if you follow this approach that he came up with, and it worked very well.



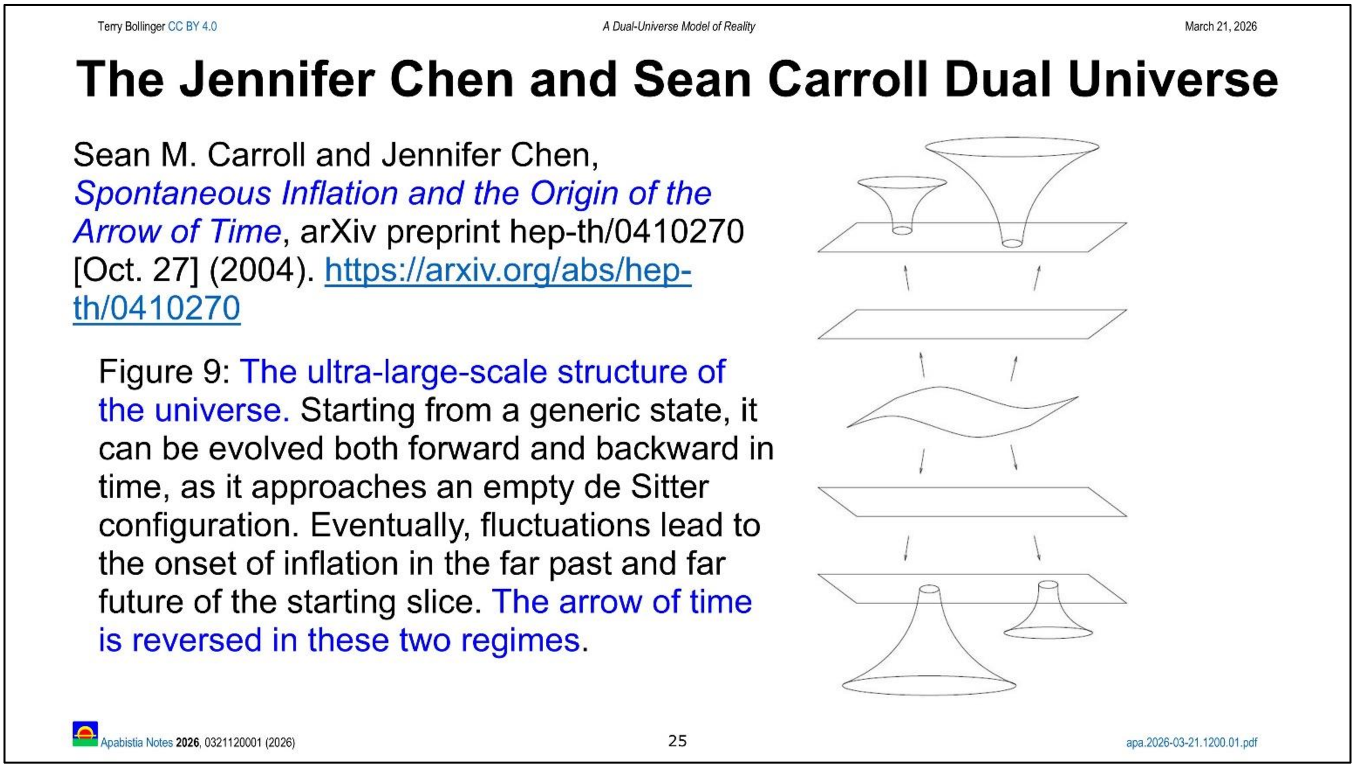

52:31 Now, oh, oh, a little tangent, this happened to me, and…
We're in very strange times, and I just want to… people always ask me, I say, well, Terry, have you used the latest chatbot for your research?
And I say, no, I don't touch the stuff in much the same way that I don't touch marijuana. I don't want my brain fogged. So, I'm sorry… sorry for AI fans out there, but that is exactly how I feel about it. I literally…
feel about intensive use of AI as the same risks of just casually using some kind of mind-altering substance, doesn't have to be marijuana or whatever, but… and the reason is this. It always, every bloomin' time I've used it, had some egregious error.
That was just wrong.

And so I always skip over those little offerings that they won't let me shut off of, say, oh, here's what AI, which is actually just a sloppy database, here's what my sloppy database posing as an AI says.
And in this case, it said Richard Feynman was extravagant, and he thought that MWI was extravagant and extremely vague.
Except that was John Bell who said that. Feynman never said any such thing.
But if you use a chatbot, which is a mindless pattern matcher.
It can't tell the difference in issues like that. If the context leads it down that path, that's where it will go.
And I literally have not had a single example in which it got something that I was aware of right. So think about what happens when you ask an AI on a topic that you don't know about.
How many things is it slipping in there that you have no idea whether they're true or not?
And my experience is, I can't get it not to make a mistake.
And that's why I don't use it. So, occasionally, I think it's about… frequency about once every 3 months, in case there's some improvement. There has been no improvement. If anything, this problem is getting worse. So, a little warning, if you're doing research of any sort, please, please, please, please, please.
I know they got the stories about this person did that, Knuth did that, Terrence Towell did this. Yes, but they all knew exactly
what was wrong. And on most things in most of the world.
Most of our activities, we don't know what's wrong, and that's why this can be very dangerous. These are not…
I hate it when they say, like, let me think on it. No, they're not thinking, they're accessing, they're going through some processes, but these are databases.
Okay, so, sorry, off my soapbox.
Oh.



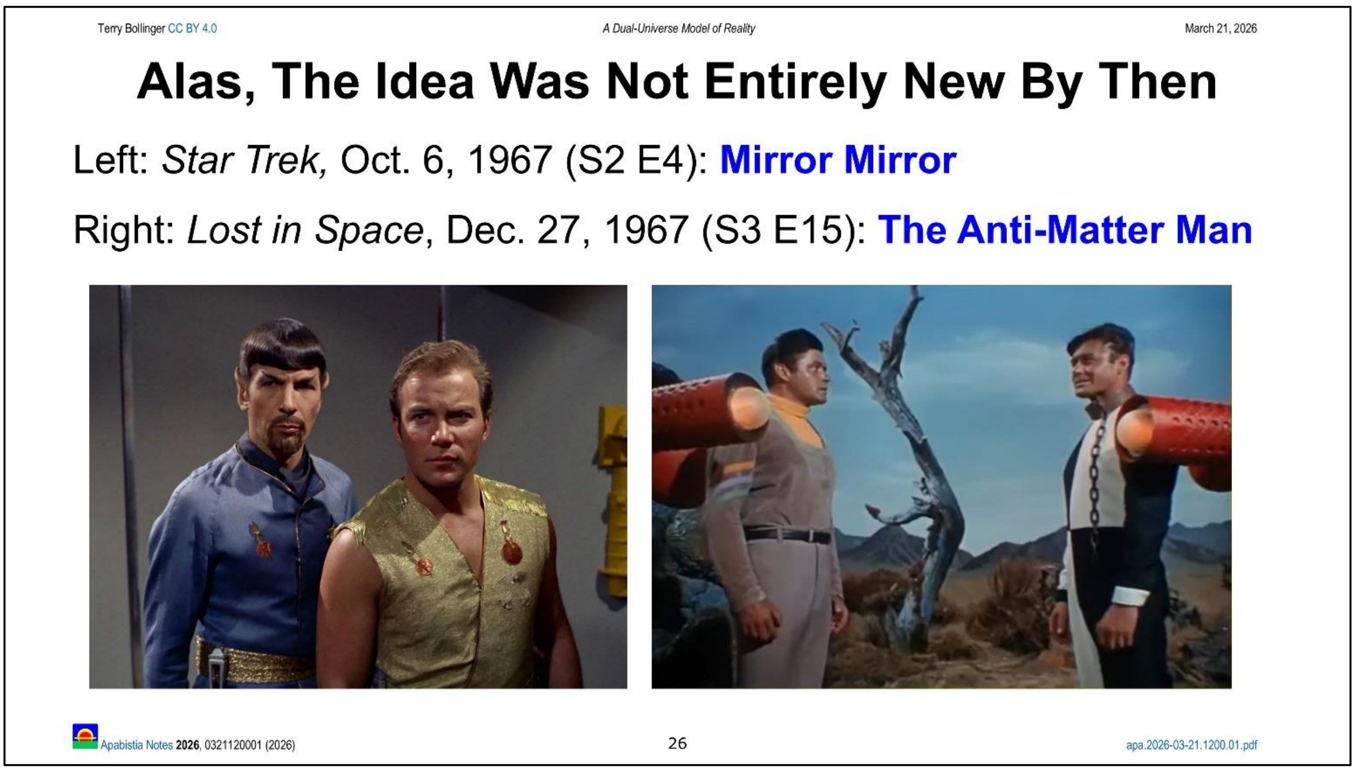

55:14 Now we get to the obvious next step. In some ways it's obvious, some ways not. The Feynman-Wheeler concept, both of those are intermixed dual universes.
So you have, like, Feynman very explicitly said, well, yeah, you know, the antimatter is a local phenomenon, and it's mixed in with our universe. Notice also the similarity to the Sidis idea again.
The idea you have a local phenomenon that involves going backwards in time.

And then you have this broader idea that Wheeler came up with, but they both stuck to one universe.
But then things get a little interesting.



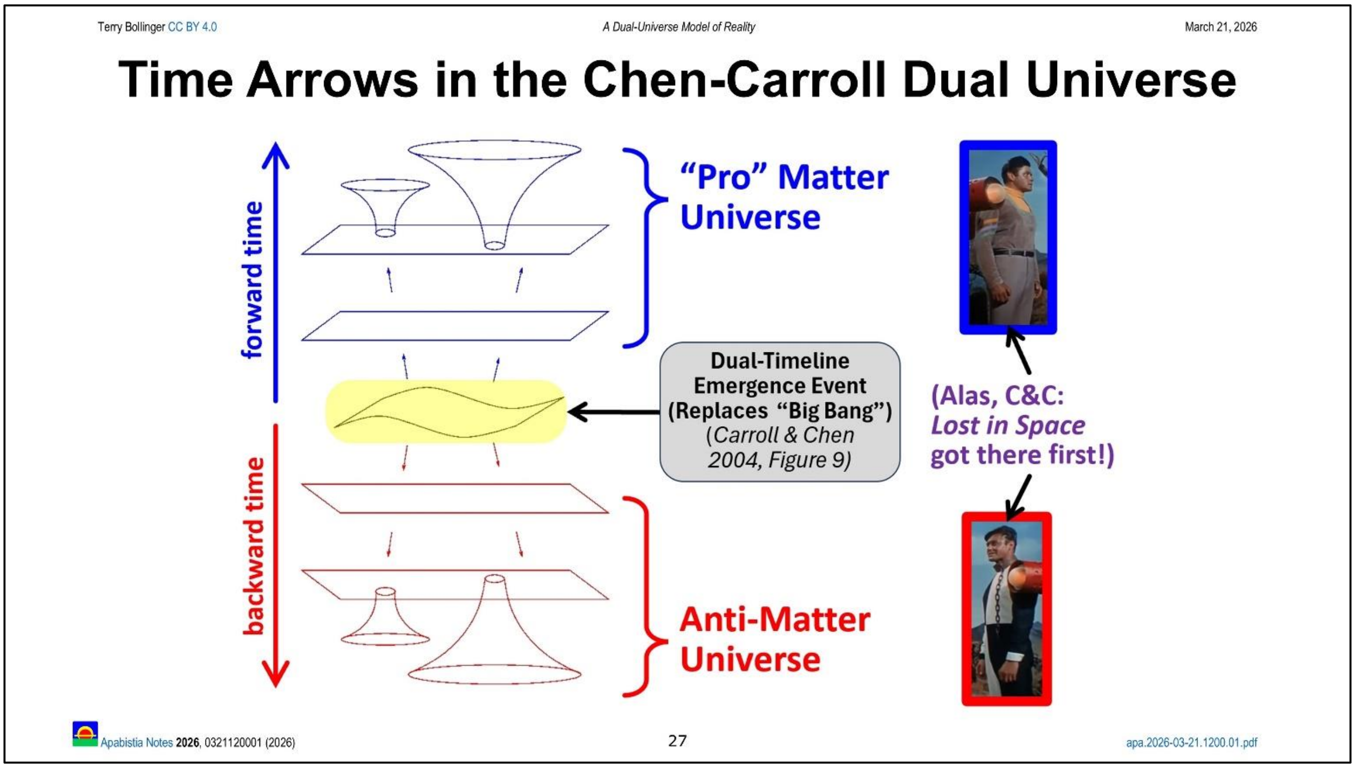

55:59 And the first place that I've been able to identify this, and I'm pretty sure this is the one where it actually pops up in a well-defined fashion, is a paper by Jennifer Chen, who is
I always put her name first just because she's not known, so I think she should get a little more credit, because I'm pretty sure she did things
like maybe this diagram in the paper. So, Sean Carroll is very well known, nobody… most people know who he is, but nobody knows. She's off in finance or something these days. But I think she should get a little credit, because it's an interesting paper, it really is.
And using arguments that start with general relativity, not with particle physics.
Using some, some really interesting arguments involving
solutions to general relativity, the de Sitter spaces. A de Sitter space essentially is
when you're talking about the universe expanding, which is, you know, a cosmological constant makes it blow apart, you're talking about de-Sitter-ish types of solutions, so there's all this whole terminology, but if you think, you know, expand, that kind of gets de Sitter, and when they say anti de Sitter.
That means contract, so, you know, there's often simpler words to attach these that give you more of an intuition. So, using,
Yeah, and also the center space is kind of a… kind of an ideal limit. You know, you want to have no matter, you just want to have space-time itself, which,
Which I do not accept as being a good… the idea of measuring something in spacetime, if there's nothing else there, what does that even mean? I'm not sure what that even means, because you have nothing to measure it with. So, you know, where are your clocks, where are your rulers?
So, at any rate, a pure de Sitter space would have this expansion capability, and they came up with this interesting conclusion, though, out of this, was that you could wind up with two
Arrows of time.
And they would essentially be going in opposite directions.

Now, in fact, I even, I even chatted by email briefly at one point with Sean Carroll, and he mentioned that he actually had favored more of a spherical approach, and this would be an actual sphere expanding out.
And, some parts in the paper seem to be like this one.
lean more towards a linear type thing, and interestingly, in my own thoughts, I did… one day apart, I went over those both… both of those possibilities myself.
So, but the net result was that they came up with this idea of saying that, yeah, you've got time going in a positive direction here, but down here.
Where antimatter in the bottom part of this, where antimatter dominates, it defines its own direction of time, so you see the difference? All of a sudden, Chen and Carol split.
That duality into actual physical universes.
And he said, well, you know, yeah, as long as ordinary matter dominates up here, the antimatter is not going to be able to win out, it just, you know, just turns into what Feynman used it for, which is just fragments for calculation.
But what if it, you know, what if it's, what if it's dominating?
And of course, another nice advantage of this is it gets rid of some of the problems, like, why is there a preponderance of matter in our universe? Where's the antimatter? Well, in this case, the antimatter's off running its own little universe.
So, a very interesting idea.

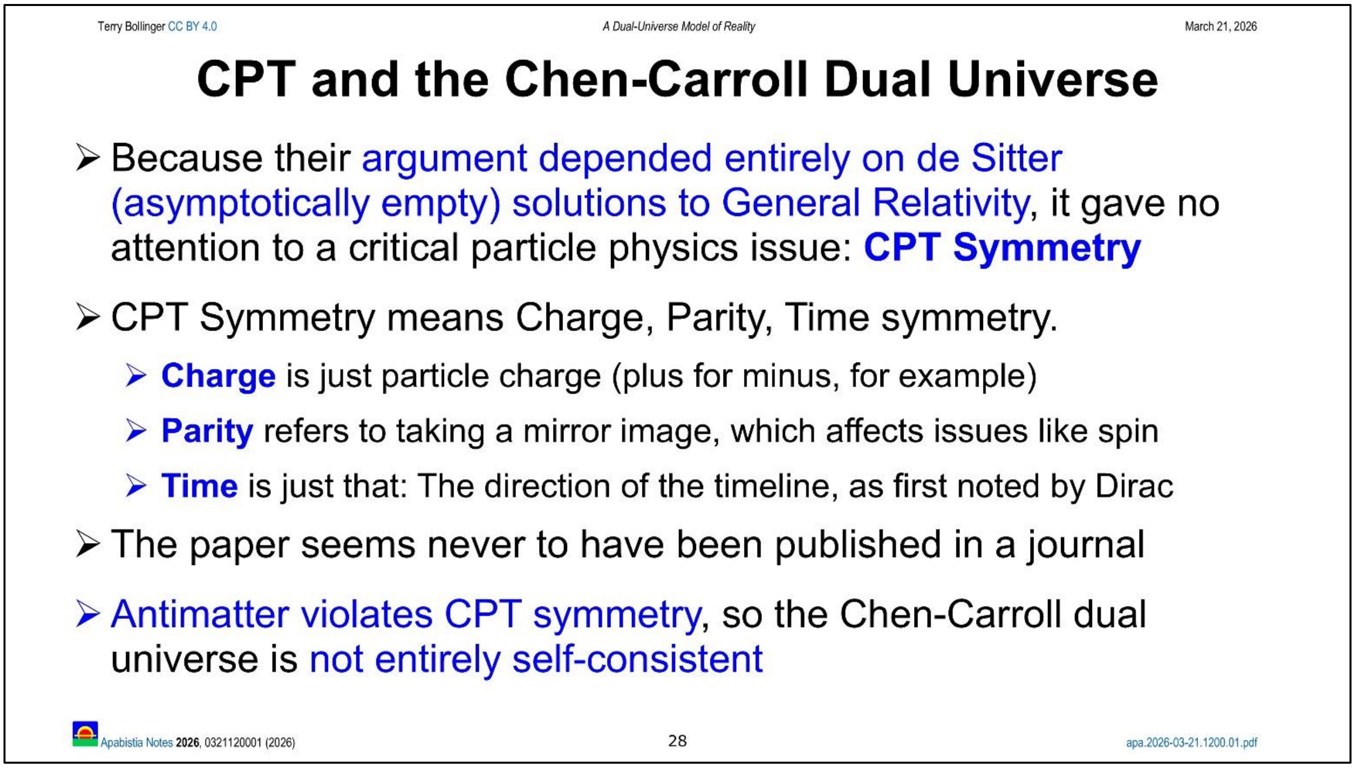



59:09 It's surprising, though. Oh, it's… it's an interesting… I can't… I couldn't resist this. My brother pointed it out, and I gotta resist this. I can't resist this. It was a good idea, but in terms of the idea that antimatter could have its own universe.
Not going through the very complicated de Sitter
algorithms they use. I mean, you know.
Chen and Carol went through a lot of work to show how gravitational structure, the structure of spacetime, could lead to this. But the idea was already out there, and two examples that are particularly amusing was that Star Trek very close together, I guess, lost in space. Some of you are very… some of you folks who are old enough may remember that one. They had an explicit idea of the antimatter man.

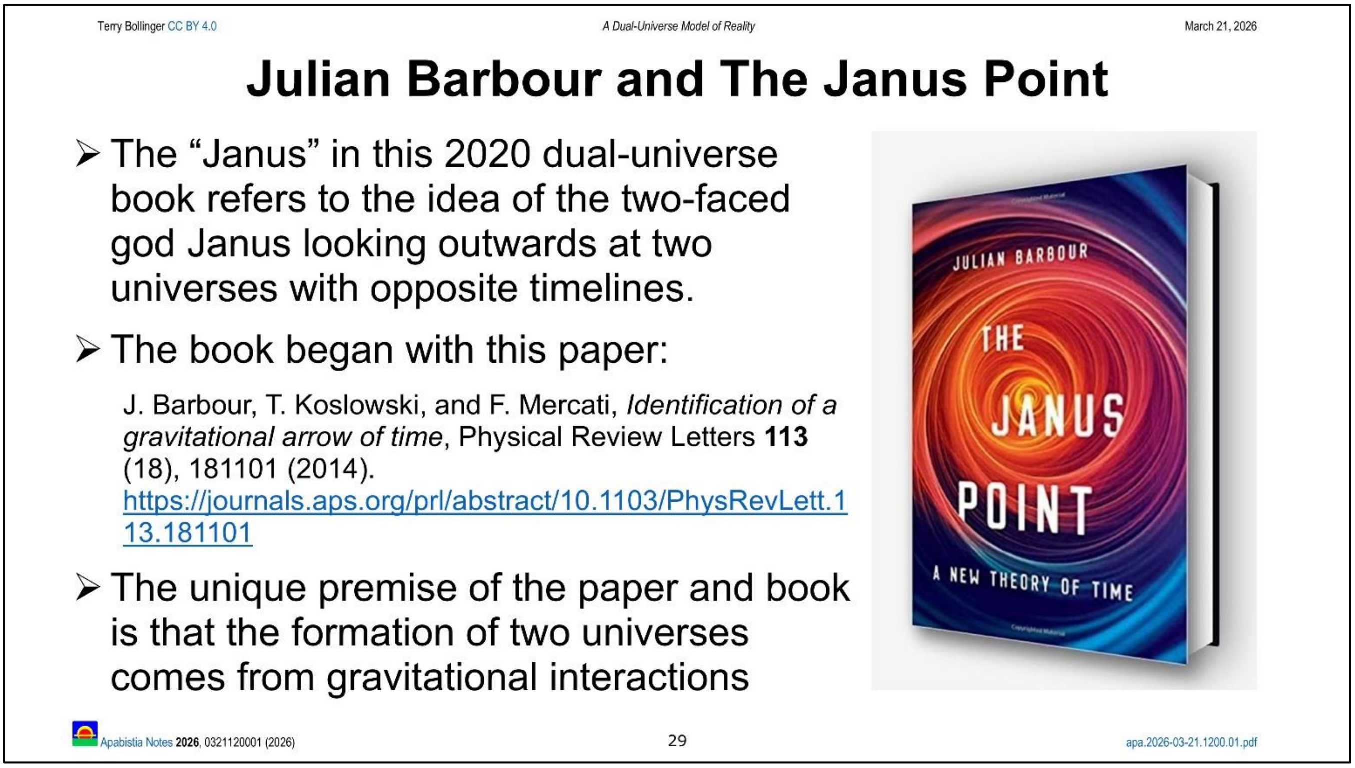
Now, if you know anything about real antimatter, you know what happens if, you know, matter is this close to antimatter. That's not a good outcome. So, not a whole lot of detailed science, but the concept that there could be two universes, one antimatter and the other one ordinary matter, certainly was out there, had been out there for some time.



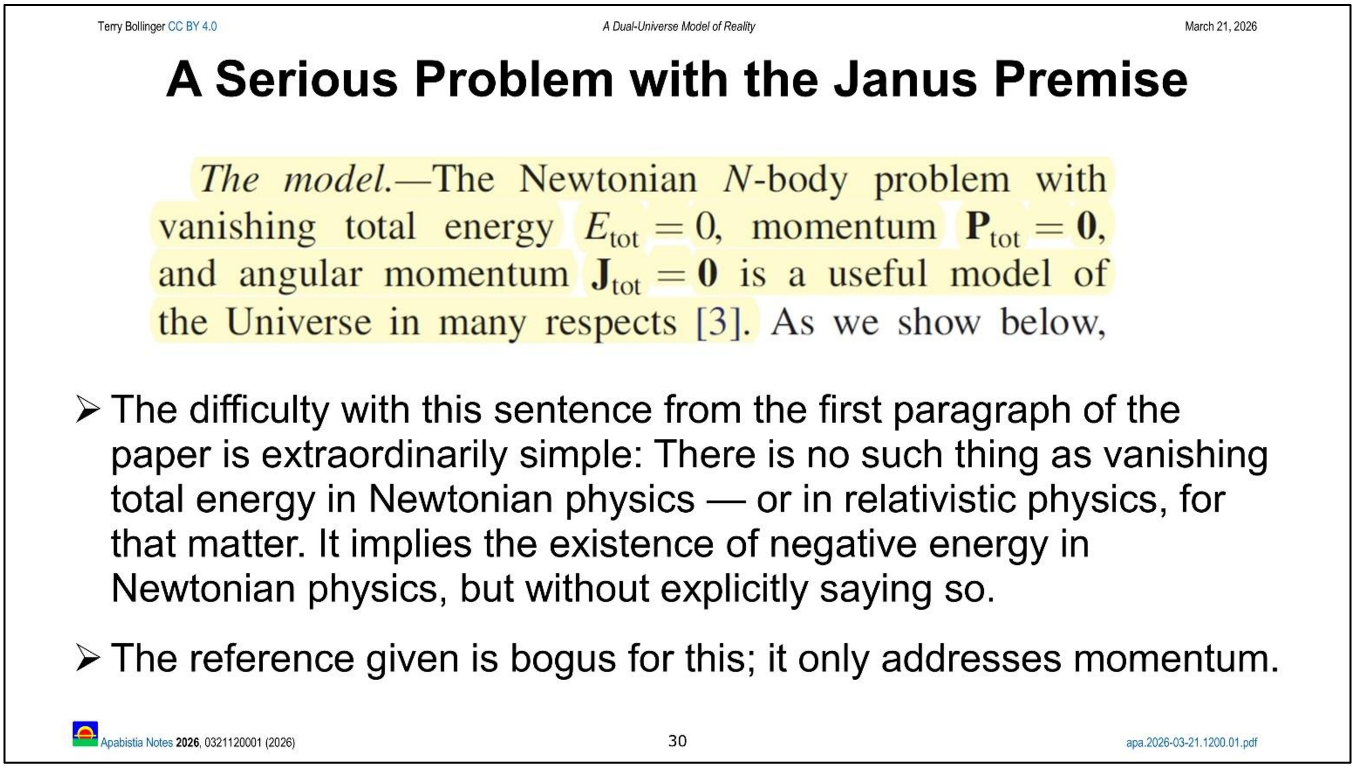

1:00:14 So, showing their diagram again, you have this pro-matter university. Every once in a while, it's good to have the term pro to stick in front of and matter, because if you talk about matter too much.
it can be a little unclear whether you're talking about the collection of all these kinds, or just that. So, sometimes I'll stick the word pro-matter as opposed to antimatter, just because it's a nice pairing.
And you get this interesting structure, forward time.
Backward time, based on which kind of matter is dominating in the equation.
And again, they weren't first. They had a much more sophisticated and interesting gravitational solution argument to get there. But as far as I know, they were the first ones to do this back in 2004.




1:01:00 There’s a problem with the,
Chen, Carroll, universe. They, they have,
Very little attention is paid in their paper to particle physics, and it turns out antimatter is not a perfect mirror.
of regular matter. So, that’s a part that they kind of skipped over, and in the end, the dual universe they proposed is just… it’s not entirely self-consistent.
The paper, I noticed, was never published in a journal, which I’m a little surprised at, because it’s a good paper, but it just went on to archive and didn’t get published, but that may have been a factor on that, is that when the particle physics
Physicist reviewers looked at it, they said, like, antimatter’s not quite as good as you think.

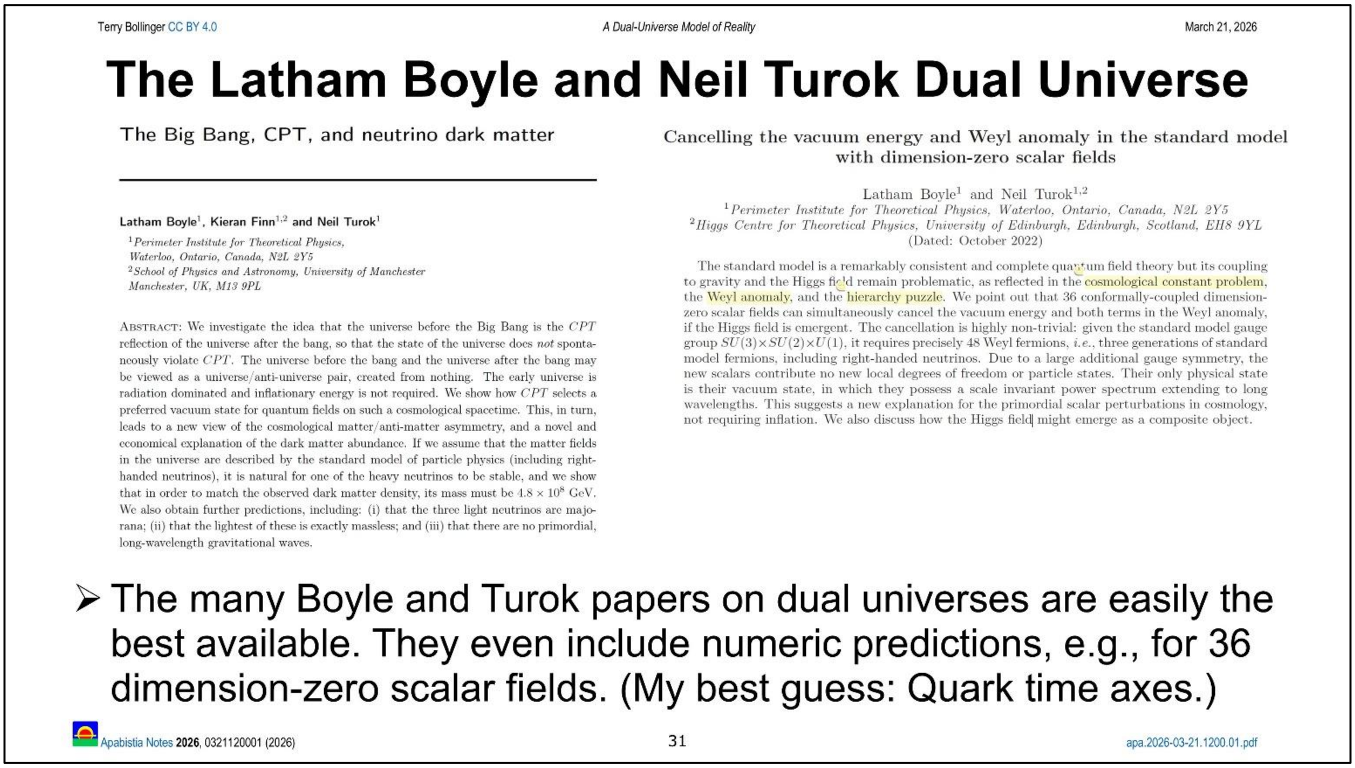



[1:01:49] Another version of this. This, this… after that, things started kind of popping, although it took a little while, you know, over the next couple decades. Julian Barber, a well-known science, self… sort of self-taught physicist. published a book called The Janus Point, and the Janus is a very explicit reference to this idea of, you know, you have two universes, you know, so Janus is the double-faced God, so he's looking this way and he's looking that way, so he had his own version of a dual
universe. Now, I have a problem with this one, though. You know, I'll get into it in the next one, but it's delightful that he addressed this, and I think it's an interesting idea he came up with.

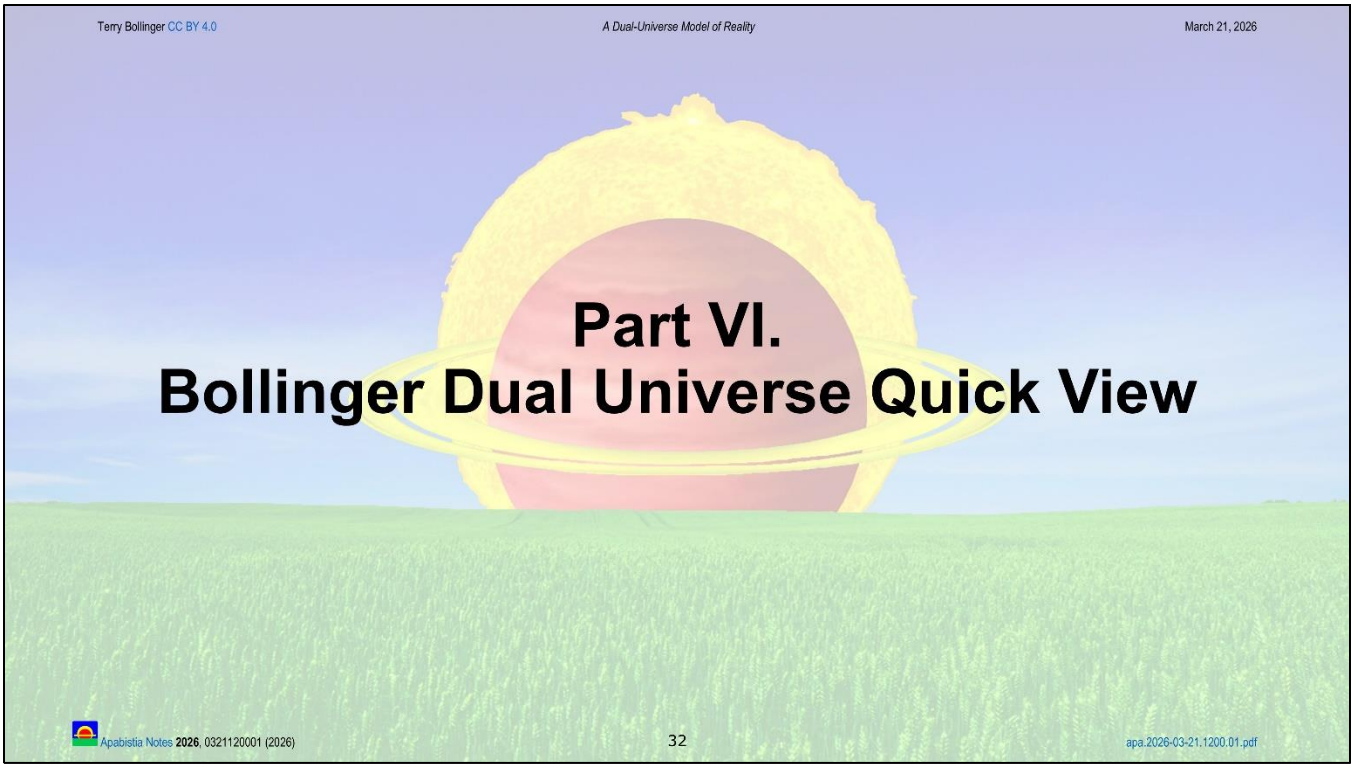



1:02:35 But when you look at the paper, this started in a paper.
And in that paper, you have this.
And this is a sentence from the first paragraph, and the first time I read that, I said, wait a minute, that's not right.
You can't say vanishing total energy, there's no such concept in physics.
You have vanishing total momentum.
vanishing total angular momentum and vanishing total linear momentum. That is, you can get them extinguished, you can get them to wipe each other out so you have a system.
that has no angular momentum relative to the observer, that has no linear momentum relative to the observer, but you can't do that with energy. You just can't.
Especially in Newtonian physics, you… no, you don't do that. So, they kind of slipped this term in here, and how they got to this point, I do not know, because
If you look at the reference, this reference 3, it does not mention vanishing total energy. The concept's not there. It's just, it talks about the other two, which are completely physical. So this is one of those cases where you have a reference that seems to support the sentence. It does not.
Now, the trouble is this. Once you assume negative total energy, you have assumed the existence of truly negative rest mass.
Anti… not just antimatter, but actual… negative energy entities.
And then what they did is they ran this through some kind of a simulation, and they found out that their universe would segregate out, just using Newtonian physics, Newtonian gravity, into two parts.
But… the paper…
I could not find in the paper where they glommed on to the realization that the reason this happened was because they introduced negative energy. So you had the negative energy parts go out this way, the positive energy parts go out that way.
So, it was an interesting result, but it would have been much more interesting if they had
Acknowledge the introduction of a non-existent concept
Because this doesn't exist in either
Newtonian physics or relativistic physics. You can't have vanishing total energy. You can propose it, in fact, I have no problems at all with proposing it as being part of the solution.

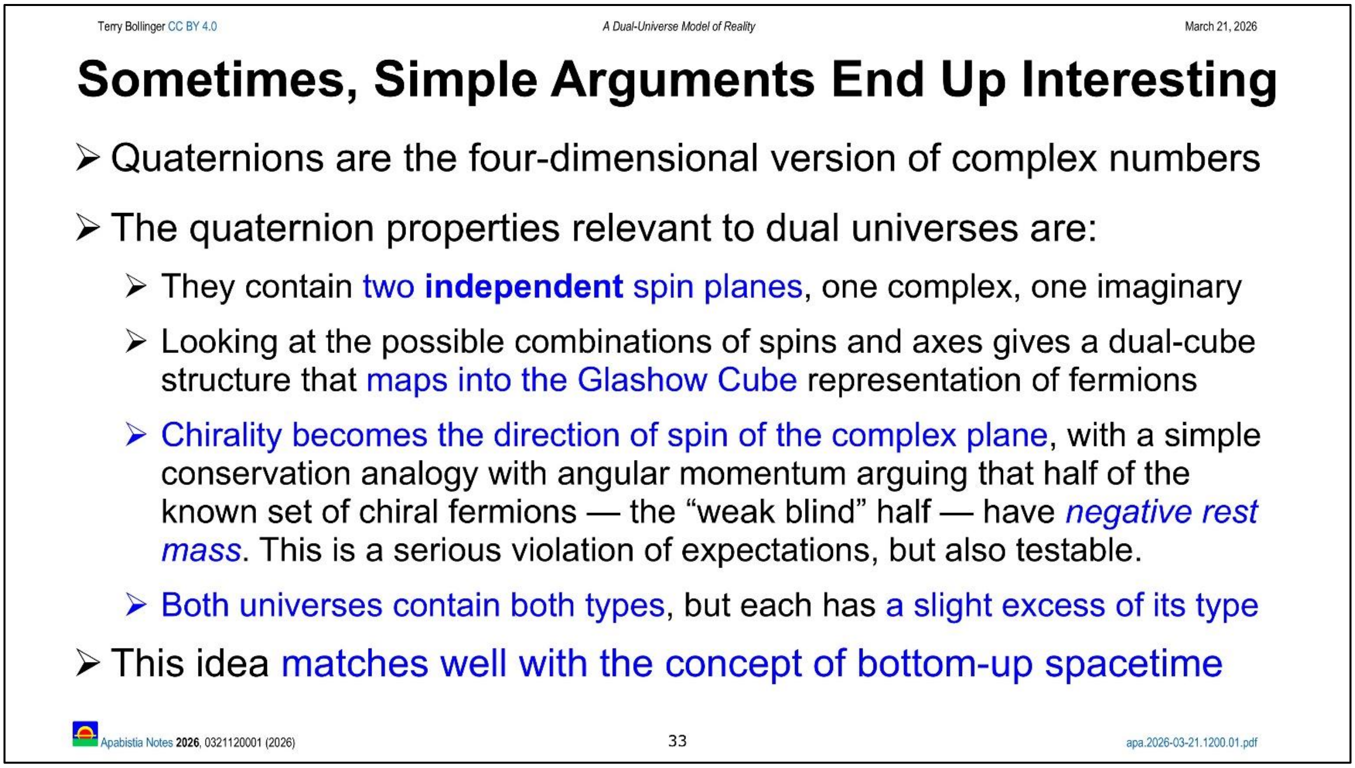
But you need to be explicit about that. So… so the Janus book, it's an interesting book, but watch out when you have a key sentence like that that doesn't quite get it.
you want to be careful about the results.




1:05:06 The most interesting set of papers on dual universes, about what could go on with this idea of two universes going your own way.
are a series of papers by,
Neil Turok and Latham Boyle. Latham Boyle, I think, is the main driver, but Neil Turek is very much a partner with it and very interested.
Those guys have got some interesting work. And one of my examples of where I say it's particularly interesting is they have an actual prediction. It's a complicated prediction, it's not an intuitive one, it's a hard one to explain.
But they, come up with the need for exactly 360, dimension zero scalar fields. Why is that interesting? Because if this
proves to be correct, and Boyle, especially, is very good on the math.
Then this is a prediction of why we have 3 families of fermions.
And that's interesting, because that's been a hard one for people to explain. Why do we have three types of every fermion with just differences in mass? So they wound up coming out with this prediction. I even have a guess on that, though. I think this is related to… now, keep in mind, a bit of a heretic.
Time is synthesized, the direction of time is synthesized, and my own…
If I had a best guess at this, the 36 corresponds exactly to the number of quark types that try to define their own off-axis definitions of time.
So I think this is a correction factor for these, off-axis, local-only definitions of time. So just a little insert on that. But, good work, and, and worth…
Worth reading if you have any interest in, dual universes. Pretty intense, so, you have to kind of dive into the math with that.
Neil Turok was the head of the Perimeter Institute for many years, by the way, so these guys are both from that background.




1:07:03 Now, I'm going to end with a quick review…




1:07:06 … because I've already *talked about this*, multiple times, in the past! If you're *really* interested, go look up some of my *past* stuff, because I don't want to just *beat people over the head* with the same stuff again!

What I think *is* interesting is *how* I came up with a dual-universe concept, which I did in 2007, which is three years after Chen and Carol came up with their general-relativistic-solution based approach.

To say that my [approach] was *simpler* is a *[major] understatement!* (Chuckle.) I am *amused* at how *silly-simple* my idea was!

It's just that I was fascinated by *quaternions*, which are the *next version* of complex numbers for four-dimensional space. So, [these hyper-complex numbers are] not trivial. But if you understand complex numbers, you kind of put a pair of them together, and you wind up with this *four-dimensional* version of complex numbers.

[Incidentally, quaternions are] very handy for doing rotations. Gamers will recognize this, because if you're a gamer, [you can] use quaternions for doing your rotations inside of your space. They're very efficient for that!

So, quaternions were something I had looked at in considerable detail. I even made an analog quaternion multiplier! You can literally make a little *mechanical quaternion slide-ruler* using some rotating things. I should dig that out some time. It was a fun little device that you could use to do quaternion multiplications.

So, the key feature is a very simple feature. In three-dimensional space, you can only rotate. You have one axis of rotation; you can't do two rotations. In four-dimensional space, you can have two perpendicular axes of rotation, and that's an idea that we can't visualize well. Because if you look at one plane, the other rotation looks just like, you know, if you're projected into three-space. It just looks like a line. But then if you rotate around, you see that line was actually a separate rotation plane of its own. So one of these rotation planes is a complex plane. In fact, arguably, it is the same complex plane that we're used to using. And the other one is just a pure imaginary, has two imaginary axes, so there's no real axis on the other one.

But they can both spin! And it turns out that the spinning of one of the planes — the complex plane — can go in *two* directions.

And one of those directions winds up giving you positive energy. So this, you know, this is not a complicated argument. It says, well, doesn't that mean the other direction gives you negative energy, and can't you then do the same symmetry that you do.

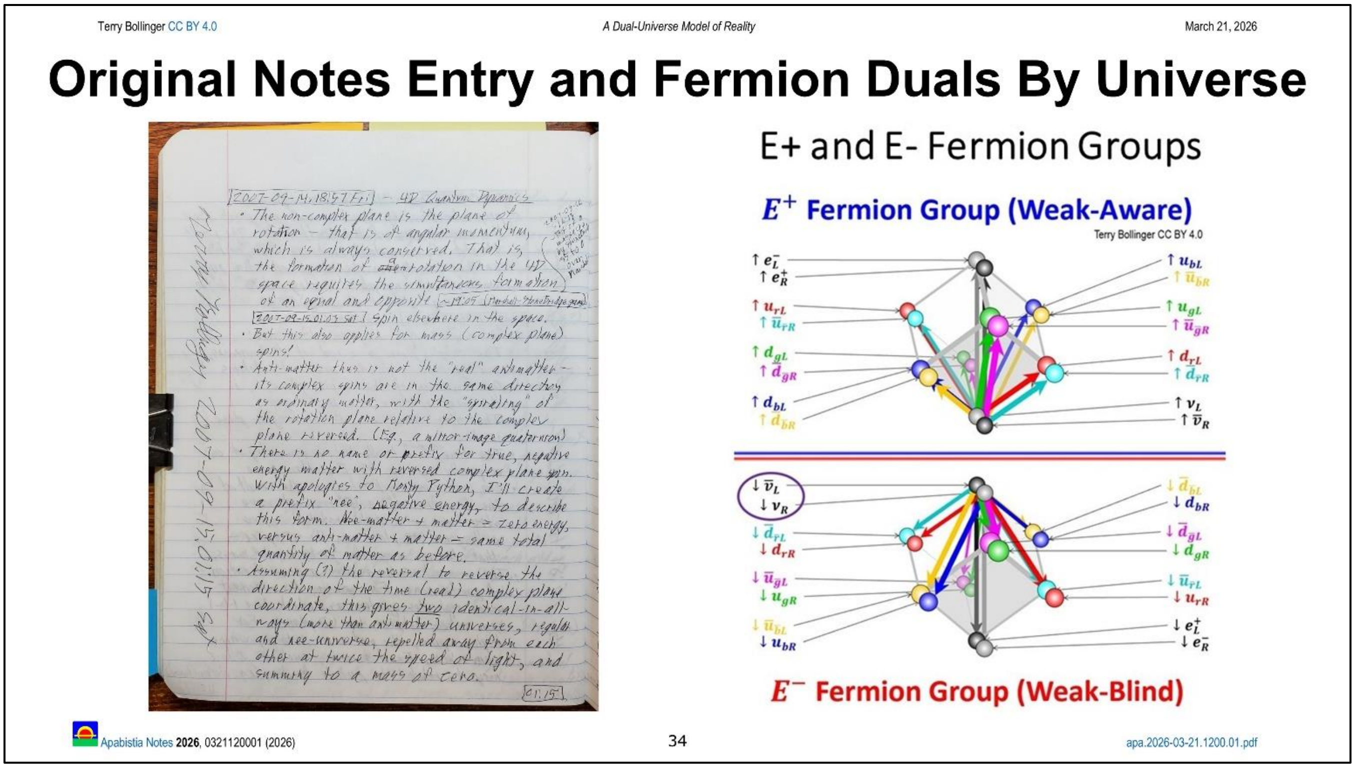
Remember [when] I talked about [how] vanishing energy [is not a thing in standard physics]? If you do this in quaternion space, then you *can* have vanishing mass. You can have vanishing energy! That's because what happens is that the [complex plane component of the quaternion can] rotate in opposite directions. One [complex plane rotation direction, e.g., clockwise] goes off into a negative energy — a *true negative energy universe*, not the [false negative energy] one that we see with antimatter — and the other [rotation direction, e.g., counterclockwise] goes off into a *positive* energy universe.

So, it's really as simple as that… but that's only looking at *one* particle. So why should *that* apply to the *whole universe?*

Well — and again, [this is mostly] from some of my other presentations — the idea of *bottom-up spacetime* has some very nice features for taking [concepts] like this and essentially elaborating them into networks… and the bigger the network gets, the more *solid* the definition [of negative and positive energy and time] gets.

In Feynman's QED, you *also* see a bit of bottom-up composition. That's because the speed of light is not defined in QED *until* you get enough participating particle [images or paths] that you actually wind up with a firm definition. There's ambiguity at the lower [individual] levels [of path definition]. So, there's this idea [in QED] that you don't have these things as clearly defined until you get a kind of consensus, actually works well with something like this.

[I've looked critically at my idea from many angles, yet] as far as I can tell, my logic holds true. It's an [interesting] hypothesis: That the spinning of the complex plane [component of the two perpendicular spin planes that are possible in quaternions] *is* the vanishing-mass equivalent. And it leads pretty directly to two *different* kinds of universes.




1:11:22 But then, [once you take the perpendicular quaternion spin pairs idea seriously,] you can get *much* more elaborate [than defining two directions of energy and time]! [You also get the fermions of the two universes.]

[The] page on the left is the one where I [first had and] wrote that down [the two-energy, two-times idea]. I was sitting at a [high school American] football game, and our football team was *too good* back then. They kept massacring everybody they played! So, I was getting *bored*, and I was thinking about some of that *other* stuff… a little football boredom!

[So, I got to] thinking about universes, and thought: "Oh, *cool!* That could actually produce *two* universes that together go back to *null*… *not* to energy."

If you put antimatter and manner together, you get *energy*. If you put *these* two together, you get *nothing*.

[On the right, the fermions of the] two universes, over here, have different [mirror-image, cube-like] diagram [relationships in which the color and electric charges correspond to not much more than different combinations of the three imaginary axes of quaternions]. [I've covered these before, so for now,] I don't want to elaborate on these cubes you see here.

[The cube diagram of fermions — of "matter" particles like electrons — is] an idea that Glashow published back in, I think about, 1980? Maybe it was 1979. Glasgow first came up with this cube just as a mnemonic for fermion particle charges, [but] it's not *just* a mnemonic, if you accept it as being a "good" data structure. [Good data structures that match experimental data closely are trying to tell us something about reality.]

[The Glashow cube] gives some insights on how these particles range with each other, and can actually help explain certain things, like, why we only see one type of neutrino in our universe. It's because the other neutrinos are in this other universe. They're there [in the negative energy universe instead of here in the positive energy one]!

Turok and Boyle go in a different direction [on neutrinos]. They still put those neutrinos in our universe, but they make them very massive. And I'm not sure if that's irreconcilable with this idea, because if these things show up in our universe, they are going to be *potentially* detectable. But their properties could be interesting to look at.

The *strangest* part, that I want to point out about what I'm saying here, is also a very simple idea: If these [negative-energy] particles exist, they *don't* just exist in *another* universe. They *also* exist in *our own* universe. In fact, not only do they *exist*, they're an *absolutely fundamental* part of how particles behave [in our universe].

That's because when you have something called a "massive electron" — an *ordinary* electron — it's *not* [a simple particle]. An ordinary electron is a *composite* of these little pairs of particles I have shown [at the corners of the] cubes? [I drew them like] that because every particle that has mass also has a *pairing* between two different chiralities — two different mirror images — of that particle.

So, you need to have an understanding of how these things interact. You need to *have* these things in our universe in order to have things like *mass*.

So you say, "But *Terry*, if you have negative mass *here*, and you have positive mass *there*… you get *nothing!"*

Well, not *quite*. What happens is, you get an *excess* — a small excess — of your positive-energy mass in one universe, and a *small excess* [of negative-energy mass] in the other universe. And that just puts them into kind of a "spin-off" situation where they *can't balance out*.

So, they just keep moving in *different* directions in time. These [positive-energy] ones go forward [in time], the other [negative-energy] ones go backward [in time], because they're essentially trying to *cancel out* and get back [to null]:

"I want to get back to *null! I* want to get back to *null!* We can't get back to *null! What's going on here?*"

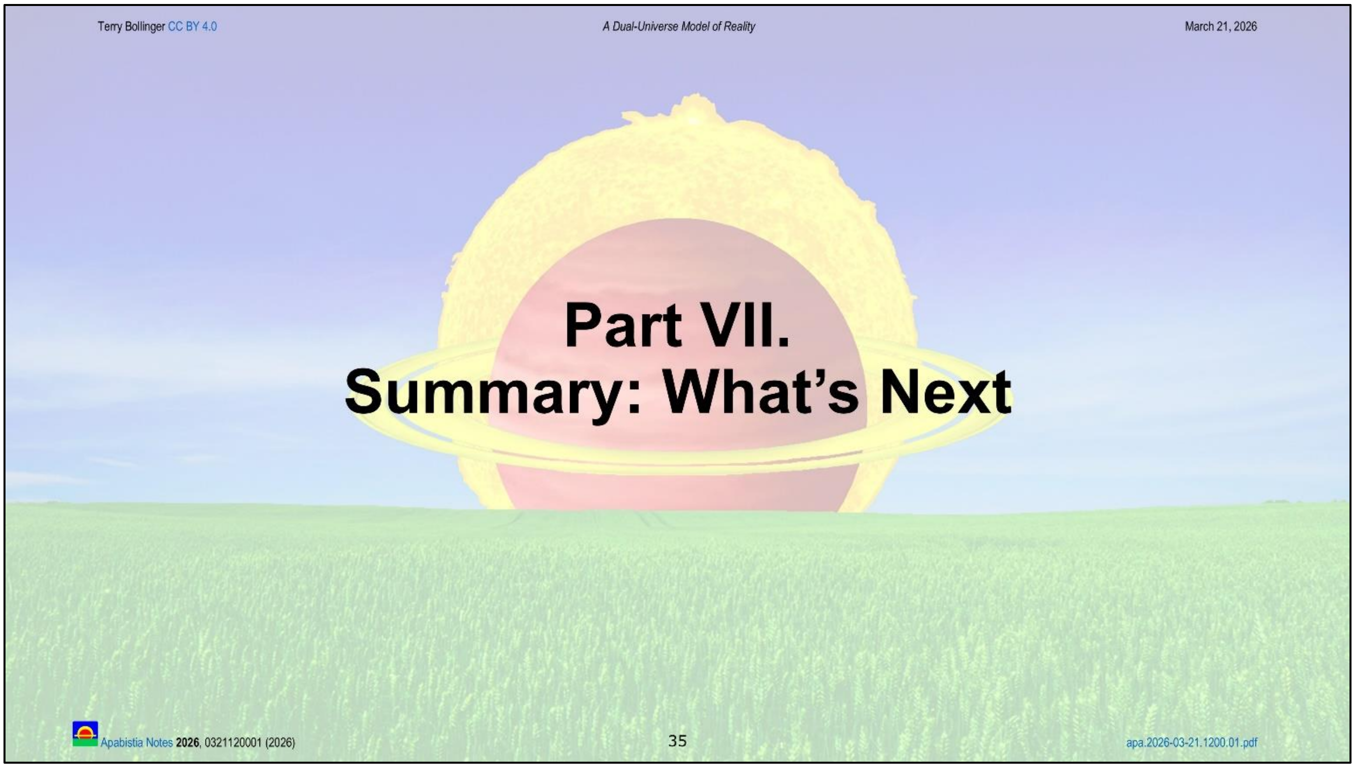
And, what happens is: They got hijacked by this *time structure*. The particles got complex enough that they produced this time structure where the central arrow — the one we associate with electrical charge — just keeps them *sailing off* [away] from the other side.

So, it's a *frustrated cancellation* where they just *can't quite* get back to where they want. [You would have these positive masses going forward in time,] and you would have these *negative masses* [going in the opposite direction].

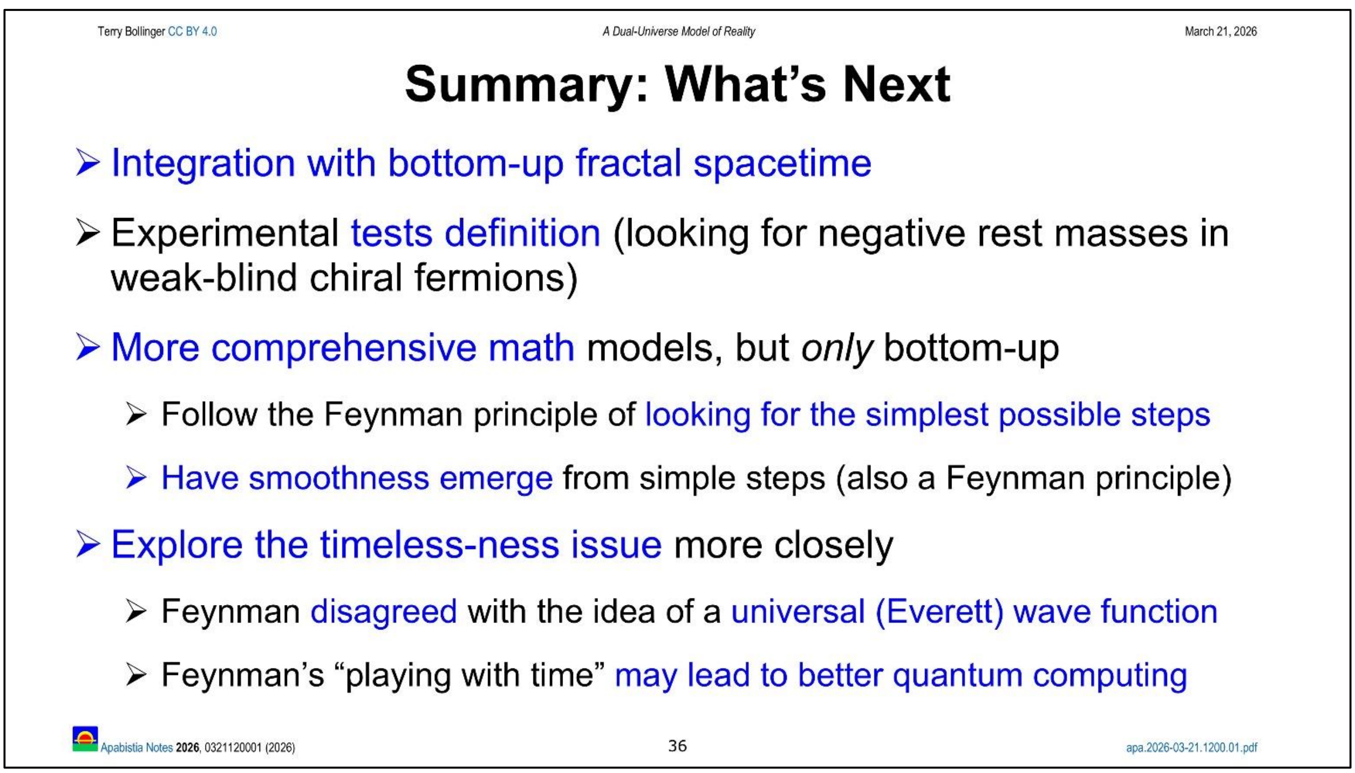
And this is, by the way, a very much a prediction: *Half of the fermionic table has negative mass*. So, how's that for blunt? You know, it's a silly-sounding idea. But what's nice is it's also *testable*, because if you say that half these particles — the ones that cannot see the weak force — actually have *negative mass*. There's *got* to be some way to *test* that!

The fact that they are so ephemeral, and they *disappear*, and that the *dominant* one is the one that you actually see as the source of the energy. That *masks* the idea [that some particles have negative masks], but it doesn't get *rid* of it. So, at some point, you would be able to *detect* these things — *if* you were actually *looking* for them.

But, like I say, it's a Terry hypothesis. Wouldn't that be *hilarious?* We talk about "negative energy" and "negative mass" as exotic concepts for *patching up wormholes*, and all *sorts* of things. But what if it's been *staring us right in the face*, all this time? What if we actually *have it in our books* — we have [negative mass particles] in our particle books! Yes, *half* of those things — *half* the chiralities of the [Standard Model] particles — have *negative energy*. And then, with a *slight excess* [of one type or the other], you get the dynamics that produce these *two* universes!

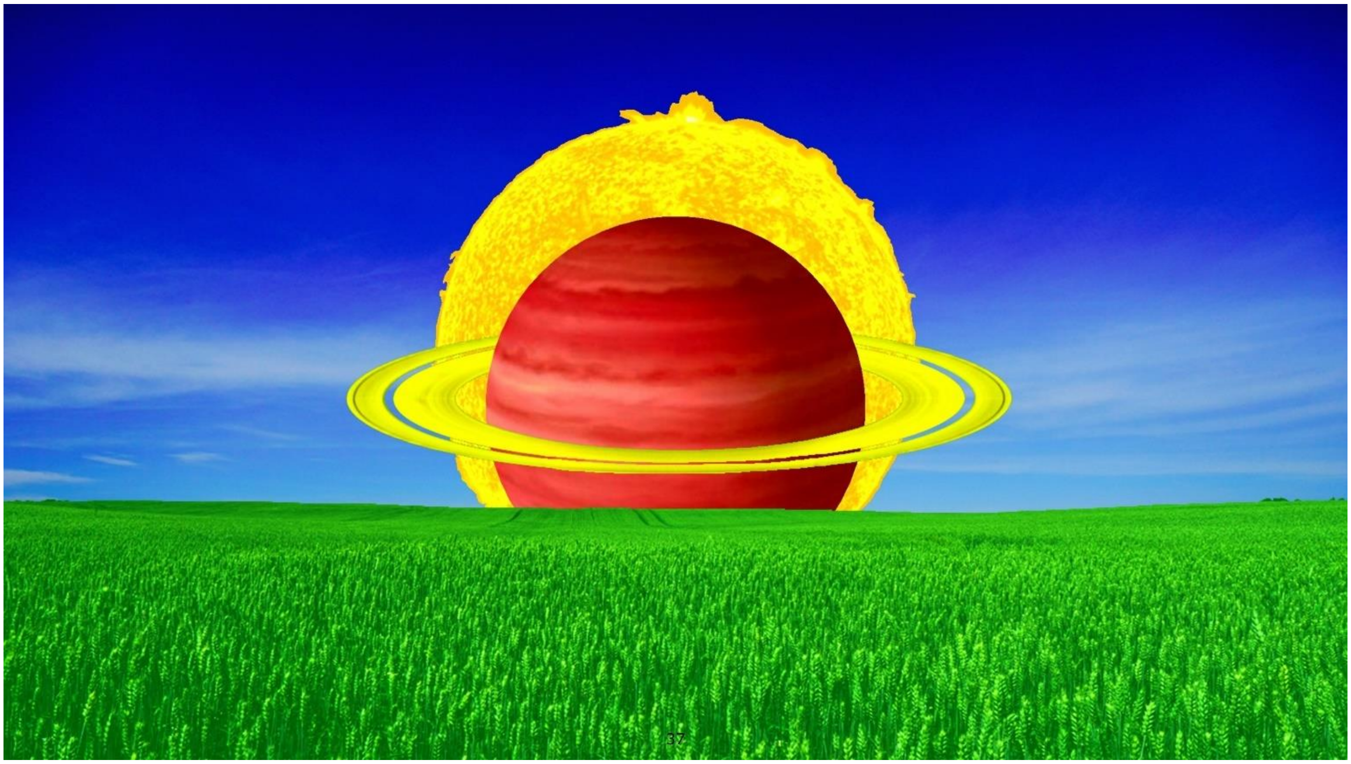



1:16:15 What's next?




1:16:17 Well… I am really interested

in this bottom-up fractal spacetime, because so many things that we do, just a simple example, when you talk about a real-time continuum.
that we use so much in mathematics. If you use bottom-up spacetime.
The only continuum you have is the one that you create, so you can have infinitely detailed numbers inside of one inertial frame.
with one set of clocks, the one set of ideas, that all tell you how space and time work together. But that's it. You don't have any more detail than that. And that's a different statement from saying that you have a space-time continuum that extends over the whole universe.
If our space-time continuums are actually fragmented, local, and dependent on cooperation between sets of material particles, boy, you wind up with a very different
Structuring of spacetime, and potentially a structuring of spacetime that could help explain some of the strange
Stringiness that we see at high levels. That could give some alternate ways of looking at that.
The other issue I really want to look at, this, this timelessness issue. The fact that ordinary photons, rely on ambiguous time, so much, so clearly.
Giving rise to all sorts of interesting quantum effects, but also particles, not just the photons, but the photons are just easier to demonstrate there.
One last comment I'll mention about, people sometimes invoke Feynman for the, multi… multi-world universe.
I think that's unfortunate, because Feynman…
was the one who looked at Everett's idea of a universal wave function, which assumes a universal continuum of space, just like I was talking about, I just said is actually more fragmented experimentally.
But it assumes that universe thing. And Feynman was one point out, said, well, you just created an infinite number of universes, didn't you?
And it… sort of like Schrodinger with his cat. You know, Schrodinger gives his cat example to try to get people to not do that. Feynman gives his example, saying, well, you don't want to have an infinite number of universes, do you?
And everybody just kind of went, yeah, that's cool! We want to have an infinite number of universes. So they went in exactly the opposite direction from what Feynman was trying to do. Why is that important? Because for quantum computing, I think it's time we go back and explore Feynman's approach.
Feynman's approach was single universe playing with time.
Not an infinite number of universes, all collaborating in a forward, expansion of infinities. Feynman, I mean, has just a much more interesting idea. And whatever this point of playing with time is, can it compute? Oh, yeah, it can. We know that it can. We see that. We see it coming out from some of these ideas of how living mechanisms at the molecular level seem to use it very well. So I think there's some interesting turf. I have talked way over…




1:19:24 And with that, I am done. …

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***Questions and Answers from after the presentation:***

HM = Helen Ma (Team OrionX Moderator)
TB = Terry Bollinger (Speaker)
CP = Caetano Peng
RB = Robert E. Becker
RS = Ron Schreiner
VS = Vijay Krishna Somaraju
WS = William Slater

1:19:52 HM: I have a question from Caetano. "Isn't the dual universe hypothesis just an application of laws of similarity across multiple scales?"

1:20:04 TB: Yeah. Actually, that's not a bad way of describing the idea, because one of the things I was,
One of the things that baffles people and physicists about time, and has for a long time, is the old mantra that, at the molecular and atomic level, there's no direction of time.
And this is not a rumor; this is just something that people have had to deal with and face for a very long time. They say, where does this asymmetry come from?
And Boltzmann, of course, was the one who first really hit this idea that there's some kind of an entropic consensus that winds up defining the overall direction of time.
So, yeah, and I think where we need to understand time better is… is just that, is, for instance, in that, that diagram I showed with the cubes.
Each one of those arrows was a direction of time.

And the only one that wins out in our universe is the one that goes straight forward, the sum of the three. So you saw that those were actually quark colors. So I would make an assertion, for instance, that time has a relationship to those color charges. Anytime you have a charge, I would say there's a relationship to time.
Time and charge, they kind of go together like peas in a pod.
So…
The reason we don't see color in our universe, why you never see color charge at a large scale.
is precisely because of the large scale. We have defined direction of time, and it is the electric-associated definition of time, the one that goes straight up in the diagonal. And that's the only one that you can invert for a long time.
But if you take that kind of approach, you just…
It just gives such an interestingly different way of looking at some of the dynamics
of how these particles interact, and I think in ways that might help us
with some practical applications for that. So yeah, it's multi-scale, and I think that's a good way to think of it.

1:22:06 HM: I got a comment from Ron.
"I think you missed the proper track reference. You showed an episode about alternate universes.
There was an episode about an anti-universe."

1:22:23 TB: Oh, was there?
Well, I thought that was the same episode, but maybe I misremembered, because they originally described it as a parallel universe, and then they described it as an anti-universe, or a paired universe. So I might have gotten a reference wrong in that. I remember that episode vividly. I thought it was actually the one.

1:22:43 RS: Well, I'm not enough of a Trekkie to memorize the episode names, but I think the character's name was Lazarus. And it starts out with them finding this spacecraft on the surface of a planet that looks like the quintessential flying saucer. It's very small. And it turns out there are two Lazaruses, one living in our universe and one living in the anti-universe. They were able to exchange positions, but they could never come together. There was some space between the time continuums where they could get locked into, and it wouldn't destroy the rest of the universe.

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BOLLINGER ADDENDUM: I later found the episode, which did, indeed, have the most dualistic discussion:

Star Trek (The Original Series): *The Alternative Factor*
S1 E28 (Paramount+ remastered edition)
https://www.paramountplus.com/shows/video/1179115052/
March 29, 1967

0:26 Spock: [This is a] very typical [planet], Captain. Iron-silicon base, oxygen-hydrogen atmosphere, largely arid, no discernible life. No surprises.

BOLLINGER NOTE: The above is a good example of why one should never take Star Trek science *too* seriously. Despite Spock's claim of "no surprises," the Enterprise will be in for a planetary-explosion-scale surprise if anyone happens to light a match in that oxygen-**hydrogen** (versus Earth's oxygen-**nitrogen**) atmosphere. :)

*[After some set-shaking and exceptionally cheesy Cosmos in Peril graphics:]*
1:14 Kirk: What was that [disturbance]?
1:32 Spock: The planet below, the mass of which we are measuring, attained zero gravity.
1:37 Kirk: That's impossible. What you are describing …
1:41 Spock: … is non-existence. …
33:02 Kirk: What would happen if another universe, say a minus universe, came into contact with a positive universe such as ours?

33:14 Spock: Unquestionably, a warp — a distortion of physical laws on an immense scale …
33:21 Kirk: … is what we've been experiencing. The point where they come into contact, couldn't that be described as a hole? …
33:30 Spock: Indeed. I point out that a hole in the universe, or in a simple container, can either allow the contents to escape …
33:40 Kirk: … or what is outside to enter …
35:13 Spock: [We are talking about] two parallel universes. Project this: One positive, the other negative. Or, more specifically, one matter; the other, antimatter.
35:26 Kirk: Do you know what you are saying? Matter and antimatter have a tendency to cancel each other out… violently. …
35:36 Spock: Precisely. Under certain conditions, when identical particles of matter and antimatter meet...
35:45 Kirk: Like Lazarus... identical. Like both Lazaruses. Only one is matter, and the other antimatter. If they meet...
36:00 Spock: Annihilation, Jim. Total, complete, and absolute annihilation …
36:09 Kirk: … Of everything that exists, everywhere.

*Discussion*: This bit of fiction — which, frankly, is no more speculative than a lot of papers that dress up similar ideas with lots of equations — is a nice example of a co-located exact-dual universe that is remarkably similar to some of the mid-2020s papers by Neil Turok, who seems to have transitioned from separate dual universes to ones that are, in some sense, co-located or even identical. (I liked his earlier version better.) It may be even closer to Einstein's paper with Rosen (only, ER versus EPR), in which they proposed that the universe has two extremely close-together spacetime "membranes." Particles such as neutrinos (the focus of that paper) then become extremely small bridges or tunnels between those two spacetime membranes. Hilariously, to me at least, those incredibly tiny perforations were the original "Einstein-Rosen Bridges," which in the Marvel Universe morphed into planetary-scale, cosmos-crossing wormholes that violate all known physics. Sometimes, even good scientists (Einstein) write papers that share more features with science fiction than with carefully measured scientific experimentation.

*We now return to our regularly scheduled transcript…* :)

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1:23:36 TB: Interesting.

1:23:36 RS: So…

1:23:37 TB: Was that the original Star Trek series, or is that one of the later Star Trek series?

1:23:42 RS: Original, yeah, it was with… Was with Kirk, yeah.

1:23:45 TB: First, okay.
Well, now you got.

1:23:47 RS: The alternate universe prevailed through a number of the alternate shows, like Deep Space Nine, yeah. Yeah, it was a story about the guy named Lazarus, and he traveled in the tiniest of spaceships. It was really almost comical.

1:25:36 TB: Oh, I do…

1:25:37 RS: Oh, goodness.

1:25:37 TB: Now you got me curious, because I don't even remember that one. The one that I showed the example of was, I think that was a well-acted episode, where they just, you saw their expression when they show up in the other spaceship, and they're looking at their own outfits, and they're… they're kind of going like…

1:24:23 RS: Yeah.

1:24:24 TB: Something happened here, you know, what happened? So it was a fun episode, and…

1:24:31 RS: Yeah, that was just an alternate evil empire. I mean, clearly they couldn't be anti, because they would have annihilated each other, right?

1:24:38 TB: And that's… that's… that's where, of course, Lost in Space was… was much, was much campier. So they did, they didn't bother with details like that, so they just have an antimatter.

1:24:49 RS: Right?

1:24:49 TB: Walking around as if it's no big deal. So, interesting, interesting. I'll look that up. Lazar…
The last one?

1:24:59 RS: I think that the character they were… the character that had two forms, his name was Lazarus, but I…

1:25:04 RB: That wasn't.

1:25:05 RS: I'll have to… I'd have to chase it.

1:25:06 RB: I don't recall the name of the episode. What was most memorable about that, I think, is the ending, the sacrifice that Lazarus had to make, basically sacrificing himself to fight his alter ego for all eternity. That was thought-provoking.

1:25:23 TB: Oh.

1:25:24 RS: Yes, in some sort of space that exists outside of everything.
Which they conveniently made up so that they could end the episode.

1:25:33 RB: Exactly. I kind of think of it as sort of a wormhole-type umbilical… Yeah.
Whoa.

1:25:38 TB: Caught in the… caught in the umbilical there. So, City, is it City on the Edge of Forever? Is…
I think one of the most interesting time travel episodes they did is the one where they find a ring-shaped device that takes them back in time.

Other questions?

1:26:00 WS: And that was written by Harlan Ellison, and it was an excellent episode.

1:25:04 TB: Yes.
Yeah, you could tell there was some good writing. I'd forgotten that Harlan Ellison was the one, but that makes sense, and I kind of remember that now.
I think they had some arguments about how to actually
Do the episode. But, yeah, that was an… Good acting, intriguing, intriguing.
content.

1:25:23 RS: Okay, so AI says it was Season 1… I'm sorry, Gemini says it was Season 1, Episode 27.
The Alternative Factor is the title.

1:26:35 TB: Here's the frustration with the chat pods, is they're so good for giving quick answers that are almost always right. And then, as soon as you dive in just a little bit deeper, oh man, you better watch out, because some of those answers are… they have…
there's fundamental reasons why that's a tricky business. But yeah, there's so… there's such a… it's such a good interface for using it. I wish it had been implemented…
in a different underlying technology, and I… I don't want to get into it, because this… this is… this is an old… this is… this is not a new issue for me at all. This is a… an issue that goes back decades, and…
I've always been an advocate of different strategies. I even had a… my name for it was Star 2000 Architecture back in the 1990s.
That went the opposite direction of what the chatbots are doing. Back then, I don't think we could have done it back then.
But it emphasized that the people are the creative element, and that's what's been lost.
In the current thing. So, for me, this hits very hard, because I keep looking at it and say, like.
No, no, this is the exact opposite of what we proposed back in 1990, the Software Productivity Consortium. Yeah, we probably couldn't have done it at that time.
But there are other ways to do this. The space of design is huge, and people are just running willy-nilly down one path without looking at the context. And, we need better context. Bill, did you have a question?

1:28:08 WS: Sure. Can you guys hear me?

1:28:10 TB: Yeah.

1:28:11 WS: Okay. I wanted to mention, two, two women. I'm always a champion of women in science, and…
physics and the STEM stuff.
One of them is, Dr.
Lenny Howe, it's spelled L-E-N-E-H-A… U.
She was from, Copenhagen.
And in her experiment, she slowed down light to about…

1:28:25 TB: Oh, yes!

1:28:25 WS: 30 kilometers an hour, and then she stopped it. Yes. And
I… I followed this lady, she was, like, one of my heroes.
And, now she teaches at Princeton, but…
To… to be so young back at the…
end of the century, the beginning of the 21st century, and to accomplish something like this, I knew it was gonna be…
a monumental accomplishment in quantum physics, so I'm… I'm one of her big fans, and she used,
The, buzzy, Einstein condensate to do that.
So I was fascinated with that. The other person I wanted to bring up that is often overlooked,
I'm one of these people that believe that we really did land on the moon six times.
So…

1:29:18 TB: Stay near the same.

1:29:35 WS: Yeah, exactly. These people put their lives on the line, and it was… it was insane, and every single one of those flights was like a test flight, but anyway, the woman… it was a woman, who got hired, to…
write the software for the Apollo guidance, system that's synced up the lunar module and the command module.
And… and help them get to the moon.
And she did two amazing things. She passed away in 2023, but she did two amazing things.
One is, she coined the term software engineering.

Yes, that term did not exist before. Her name was Margaret Hamilton, and that's an unfortunate name, because Margaret Hamilton was also the person
who played the green-faced, Wicked Witch of the West in The Wizard of Oz.

1:30:31 TB: Oh, boy.

1:30:31 WS: But, yeah, but Margaret Hamilton, she was a Midwesterner, she was over at MIT, and she wrote, all these lines of code, for the Apollo guidance.
computer, and the other thing that she did, they would not have gotten to the moon if she hadn't written this logic in her program. And the logic basically stated, look, we're handling multiple things at once, so if we get overloaded, let's start dropping, the, non-essential task
Because we want to be able to, allow the processor to do its function, so let's just disregard
And, and trash the, non-essential task.
That was a very early form of artificial intelligence.
And, and people…
That… that have studied how to write code have gone back and studied this, and now they get smarter because they realized this woman really had it going on back in the 60s, and she saved a bunch of astronauts' lives, because we couldn't… we couldn't have done what we did without her, so I just… I wanted to bring up those two women, Lenny Howe and Margaret Hamilton.

1:31:47 TB: Margaret Hamilton… I do not recall Margaret Hamilton's name. I remember the other one very well. I was just amazed by what she had done with that slowing light. I thought her use of lasers and the states, that was so cool. It was clever, and the result was just amazing.
And, good work, so I'll try to remember that. It, it, it grieves me that so… what happens so often.
Way too often, is women have done incredible work
And then some guy just tastes it.
And sometimes it's blatant, sometimes it's subtle, sometimes they're the one who goes to the conference instead of the person who actually did it, but you take your permutation of it. In some cases, it just literally will outright take it, put their name on it, and pretend it's theirs.
And it just… it's… It's terrible that…
we… I think we're getting more aware of it, but… but…
Anything we can do to stop
you know, stop people from grabbing other people's ideas and just… and going at it. That's…
So, good examples, thanks on that. And I love that laser work. I could go back and look at that again, because when she stopped it completely, that was especially amusing. Like, how do you stop a photon?
And… but she was solid work. This wasn't… this wasn't baloney work. This wasn't just, you know, kind of interpreted a certain way. Like, you could certainly see that in some of,
There's been, like, the quant… oh, the, the simulated, black hole, or tunnel, quantum tunnel. That was… that was terrible, because it was just… it was just words.
And in contrast, you see her work that is so solid, like, you know, get in the lab, do it. There's another,
I can't remember her name right now, that's terrible. Really good physicist, she's,
I'll try to remember for another time, but she… I remember her advisor tried… somebody tried to get her interested in string theory, and she just kind of looked at it and said, like.
I don't see this going anywhere, which is a pretty good prediction, considering how many decades and how many Human hours have been… have been spent on that without a single, A single prediction?
So, but she… I liked it. She had a common sense, like, I don't think so. I'm gonna look at something else, and she's done some really interesting work.
on relativity. Can't remember her name. I'll try to remember it for another presentation.
Ron, you had a question?

1:34:23 RS: Yeah, actually, it was about your slide 10 that graphic of…
a three-dimensional representation of an electron in… inside of a copper… I assume it's a copper…

1:34:36 TB: Oh, yeah, yeah.

1:34:37 RS: Crystal?

1:34:38 TB: Forming service, yeah.

1:34:39 RS: Yeah, and the gentleman who rendered it,
I assume that that's a three-dimensional… Probability distribution?
It's a little.

1:34:53 TB: Well, it's a… well… Oh, that's an interesting question.

1:34:57 RS: Or is it something more like a wave… some other type of wave function, or…
But mostly, mostly what I want to know is, is there anything in… would there be anything interesting inside of that shape?

1:35:41 TB: Yes, other electrons.
The… what are you looking at…

1:35:44 RS: More than one electron?

1:35:15 TB: Nested. What you're looking at is nested.
And I don't think I'd call it a probability distribution, though.

1:35:24 RS: Okay.

1:35:25 TB: you tried to sample it, it would… it would become one, so that's why I'm pausing a little bit. There's an interesting relationship on these things. It's the same thing that happens on any kind of metal conduction. When you… when you're…
when it's conducting electricity, it's a wave function. But when you… as soon as you try to say, I want to look at a particular electron, then it becomes a probability function, and those things are the momentum space representation of that phenomenon.
So, those coordinates were three-dimensional coordinates, but they were three-dimensional in momentum space.
And they showed an energetic electron that was on the outer shell of, like, a hornet's nest, or one of these, what do you… one of these, what do they call it? Little Russian dolls, where you have a…
There's a name for those.

1:36:10 WS: It's called Metrojska.

1:38:41 TB: Yeah, but you have these… they're nested, they're nested, and at the very center of that is the lowest energy electron.
And, it could also be atoms. Atoms can also do this. If you look at some… the Mossbauer effect, it just is this amazing effect in which you can access the coldest atoms on a… on a bar.
Using gamma rays, which is just weird. You know, gamma rays are so incredibly energetic, and yet the atoms will respond and say, yeah, I'm chill.
I'm at the bottom of my… my momentum space.
I am super chill. And if you budge me even the tiniest bit, I will stop accepting your gamma ray.
And I saw a guy doing this experiment live once, and I was asking him some details, and they could move that bar at centimeters.
You know, like, centimeters per minute, just at a really slow rate. And this thing would pick up the fact that they were moving it.

You can't do that classically. That scenario does not exist classically. Only quantum mechanics can give you that kind of strange behavior, and it is involving exactly the kind of… in that case, it was a nesting of the vibration modes, not of the electrons, but of the vibration modes of the atoms.
So that you actually have vibration modes where some atoms are absolutely rock solid still, and saying, I ain't moving.
And then you have other ones that go on that, so you would… you would have a similar type of shell diagram, probably not as intricate.
If you tried to map, map those molecular vibrations out.
So, I love momentum space. It just… it gives you these…
Crazy things, and again, that shell, that was one electron. That's not a bunch of electrons.
That shell was one electron. That's what the electron looks like in momentum space, because it has to equalize out on all directions, and then the structure of the metal gives it all these weird… the crystalline structure of the metal gives it all these weird angles and things. They call it reciprocal space. This is a… this is not some unusual… method. This is a standard analysis technique for working with metallurgy and some of the things you might do, so it's actually very commonplace for some folks. But the meaning of it, and again.
People do skip over the fact that these shells are the actual particles.
Yeah, what does that even mean? Because it's gigantic, you know, it's quite big.
But, you have to drop some usual concepts of how the coordinate system works.
Other questions?

1:38:41 RS: Are you aware if he used a set of equations to render that image, or [is that experimental data]?

1:38:48 TB: If you look in reciprocal spaces, I think in Wikipedia, you can find more literature. It's a combination of equations.
And, a lot of actual data from that particular… I believe that one… I think that one was based on actual data. I don't think that was just a simulation. I think that was a representation of the data they were getting from that particular metal.
Under that testing. So again, this is… this is… for certain people, this is… this is an active, experimental thing that they do. It's how they characterize the reciprocal space, and that gives you a lot of important properties of how the metal is going to behave.
And also how you might produce, you know, useful allies. All of these things affect the behavior of the metals.
I mean, metals are weird, and strong, and all sorts of things BECAUSE they're so quantum.
Whereas, ceramics, the quantization, the quantum effects are very local, so it's just atom, stuck to atom, stuck to atom, stuck to atom, stuck to atom.
Metals, that's not the case.
You've got those conduction electrons, and they're out doing all sorts of very unusual things that give us some really delightful properties. So you want to see something quantum mechanical? Pick up a piece of metal!
Look in the mirror, you know?
The other one I always point out is, look at the fact that you have volume. Look at the fact that I…
Can't do that. That's not electrical. That's… that's very quantum, that I… my hand doesn't go through my other hand. There's a little bit of electrical interaction that's often gotten incorrect.
on some science videos. I don't know why the… sometimes these things get ingrained and people keep repeating them. There is a modification because of electrical charge, but it's a minor one. That's the Pauli exclusion effect. It's why you don't go through your chair.
And it's just one of the most…
Important effects for our existence that there is.
And most people… a lot of people have never heard of it, so…

1:40:42 RS: Well, if there are actually equations behind that rendering, and if there is
The possibility being stuff interesting inside of what looks like an amorphous blob.
Whether some sort of a tomographic technique could be to slice through it and see what's in there.

Which, should be easy to do up there if it's equation-based, but, if it's data-based, it could be a little more difficult, I think.

1:41:11 TB: That's interesting, because what happens is the shell that you see is always the surface shell.
The inner electrons are the ones that you can't see, because only the ones that are at the very outermost limit interact with the coordinate system of XYZT.
And the other stuff is kind of verboten until you break it.
So, if you send a gamma ray in there.
send an x-ray in there, and you can pop one of those inner shells instantly. And that's where it becomes a probability function, like you said. So you can shoot it in there, you can pop one in a certain… you could probably tune it down to get a specific layer
inside of that shell. In other words, you're looking for the electron… just… actually, the moss power is an example of that.
The mass power is an example of that, because the mass power in the thermal domain, in the vibrational domain, not in the electric domain, but it's the same math.
You're looking… you're actually focusing the gamma ray on the lowest…
Innermost, member of that shell.
So, you can certainly do that for electrons also. I imagine if you looked in the literature, you could find it. But you send an electromagnetic ray of the right frequency that would tune in to that particular shell, and yeah, you could start, you know, whacking it.
There have been experiments done, just to see if there is any possibility that electrons occasionally fall.
And they just say, oh, oh, heck, with this momentum space, I'm just gonna drop to the bottom and lose my energy.
And of course, the result was, as expected, as the experiment is expected, is that that doesn't happen.
These, these fermi seas, as they call them, are very dense, and they… they… they take no prisoners. They say, like, you know, you, you can't come here, you stay out.
You know, unless you give me a whole lot of energy, you're not getting in here.
So, yeah. So it's a combination of equations, but I believe that was a…
I'd have to go back and look, but I thought that one was a data representation of the outermost Fermi shell
of a particular copper or copper alloy, under some circumstances. So…
the equations… you have to have some equations to convert it, because, of course, your Fourier transforms, mostly, that you have to convert that into the momentum space representation, or reciprocal space representation, which is where you get these beautiful objects. Oh, you just… it's just… I love looking at some of these things, they're all…
All gnarly in different shapes for different metals.

1:43:42 RS: Sounds like a challenge. Thanks, Terry.

1:43:45 TB: Thanks.

Bill? Bill, I think you're muted.

1:43:55 WS: Always trying to be a good, video conference citizen.
I put this in the chat because,
It came up this week, somebody revealed the existence of,
this new fractional second, it's called the zeptosecond.
And the humorous part of me immediately thought of Zeppo Marx.
I am.
And maybe that's who it was named after, who knows?
But, but, I put all these, scales in there so… because, when we start talking about
subatomic… Phenomenon.
It's useful to understand the scale of the physics.
And so I was, I was, familiar all the way up to attoseconds.
But this is not… this is not just, some comic book, fabrication.

Apparently they've come up with some… they've come up with some experience
I know, experiments that show that
They've been able to measure stuff down to the, like, 200 and…
267 attosecond level, and so they're… they're targeting stuff into the zeptosecond range, which is 10 to the negative.
21st Power, so, to kind of help people get their, their head around this, I…
I didn't know how to write the superscript,
and Zoom, but I created a little chart on the fly
That… with all these terms, so that when people start talking about
picoseconds, and petaseconds, and attoseconds, and zeptoseconds.

1:45:35 TB: I've never heard Zepto… you're the first time I've heard Zepto come up in measurement conversation, and like I say, they keep pushing it, keep coming up with some… I would not have expected that they could get That… that's… that's interesting.

1:45:49 WS: Sure. So, maybe they'll name the 10 to the negative 24th, Bollinger seconds or something.

1:45:56 TB: Well, I was thinking that, you know, if the old communist regime Russia still existed, they might… and they came up with this, they might call it the Zepto Marx.
So, you know…

1:46:08 WS: Sure.

1:46:10 TB: I don't know, it's… do you know which lab was doing this?

1:46:15 WS: You know, I'll look it up, because I screenshotted it, and I'll email it.

1:46:21 TB: Oh, yeah, I'd be curious to see that. I love it when they start pushing those limits like that. The recent results a few months ago on quantum interference of dust-sized particles.
That was clever. That… I love… that's what I… I love to see it when an experimenter says, we keep thinking in the same way, let's just change the entire setup.
and do it a different way, and that's what they did. Sure. And then it opens up a whole new, pathway by which they can do that. But, the fact that,
Virus size, you know, the fairly large objects can go into these quantum superposition states.
And no one's seen a hole in it.
You know, people kept thinking, like, well, this is so weird, it's got to break. I don't think they're ever going to see a hold of it, because I think… I think we got it backwards, that the quantum world is first, and it's our world that is just a symptom of it. And if you think of it that way, you say, no, it's never going to break, because we're just… we're the ones who are benefiting from that, not vice versa.
You know, there's a subtle assumption we can make that the world is classical first and quantum second, and I don't… I so don't buy that. I think…

1:47:30 WS: Me too.

1:47:30 TB: classicality is a marvelous… and it also… in some ways, it undermines classicality. I think the fact that classical physics exists is so important.
And it's literally why we're here, because you can't have an information universe without classicality. So it's like the greatest gift from the quantum domain is that we can be almost, almost, not completely, but almost classical in a lot of ways.

Sure.

Other folks?

1:48:01 CP: Can I comment a bit?
About, I think, what William Slater was talking about.

1:48:07 TB: Oh, container, I think. Speed of light.
Yeah, I can… Can you hear me?

1:48:13 CP: Can you hear me now?

1:48:14 TB: Yes, yes, I can.

1:48:15 CP: Yeah, I was saying, William Slater, earlier on, he mentioned about the slowing down of speed of light. I just remember that that happened also in Scotland. In 2015, the scientists at Glasgow University in Scotland and the Elliot Watt University, they managed to slow down the photon in free space, too. So, that's just a comment.

1:48:43 TB: Yeah, there has been some cool… you see that was free space, so they were using.

1:48:47 CP: Yeah, in free space, yeah, they might… I think first, first in some kind of medium, and then they… and that… that carry on in free space with slow speed as well.

1:48:58 TB: Light is so amazing, you know, the things it can do. In my pocket, I've got a little device from,
From the, beautiful.
I'm forgetting their name right now, but they do have… Olight, but they… I have this little pocket, flashlight.
that has an ordinary flashlight, multiple levels, including flashing, but then it has a green laser, and then it has an ultraviolet light. Just the fact I can get all those different kinds of light in my pocket, and then just compare them one by one, you realize how much detail and structure and complexity
Light can produce so easily.
And, you know, I think we kind of pass it off as just, well, you know, it's just photons are just waves, but…
Look at the…
the complexity of what you can do on even a simple device like that. So, amazing stuff.
And I love it when people push those limits experimentally and see what they can come up with.

1:49:57 CP: Yeah, Terry, just a quick question, a bit philosophical, maybe a bit physics as well.
You know, the theories, when we try about dual universe, or whatever, multi-universe, whatever theories that are out there, my problem is, will we ever, ever
Prove it.
these theories, or the hypotheses, actually, they're not theory, they're hypotheses, in a sense. Will we ever be able to? Because if you look at the Big Bang, we may be able to…
To read the measurement from measurements, we can see that, you know, the universe might originate from a big bang.
Now, about the crunch, the big crunch, that is a future.
Now, whether the… if we can do the reverse entropy, or, like, the reverse time.
If we could also read future, you know, for this… the future entropy, perhaps we'd be able to see if the Big Bang is gonna ever happen.
If that, perhaps, would be able to, to, to, to, to, to…
To prove the hypothesis. But otherwise, it's almost impossible. And also, our lifetime as human being, we may have another 5 billion years, and we may not see what's gonna happen to the universe.

1:51:25 TB: What I think is going to happen is, of course, obviously, we cannot observe it directly, but the example I would borrow is DNA analysis. If you see some of the papers that are coming out now, they're saying unusual things about saying.

When did funguses diversify? And they diversified, like, 2 or 3 billion years ago. And you go, like, how can you possibly know that? You can't even… most of these things don't even fossilize.
And the answer is that we have sources of information that we didn't realize, that when you put them all together, they can give answers that… that we don't… that we didn't think were possible.
And, and they come out with, some very interesting features in that. I think in the case of the fate of the universe. I honestly think we're being blocked by our own math models right now. We went down so hard and heavy on these extreme continuum models that are just… mathematicians love them, but they're limiting in some ways, and that seems like a strange statement to say, but I would say that, because the unconscious assumption that I think you have to be careful about with continuum state models
continuum space models, is that they're very, very classical, sometimes in subtle ways. So you think, say, well, I'm describing general relativity using this math, and you say, but yeah, but you're also
assuming an extremely specific set of relationships between every point at a level of detail that cannot be achieved with any physical mechanism. I think we need to get some more variation in the math, and I honestly think that at some point, we're gonna see some of these things do a bit of a collapse, and you say, "Oh… *oh! That's* what that was! No wonder we couldn't figure that out!

I think science is getting ripe for one of those over the next decade or so, where they can kind of go like, "Yeah, we need to reinterpret some of this." We still see what we had before, but we're getting some new insights.

An example of data like that is the stringy, stretchy, spirally, weird structure of the overall universe. We just keep doing the dark matter models, which are parameter models. Yeah, you put in enough parameters, you can model anything. That doesn't mean you *understand* it. You know, if you can get a *minimal* number of parameters, then you have some understanding.

I think the universe is trying to send us a very hard message saying, "There's more to me than you think" — and we're still not listening very well. We still want to try to stick with *exactly* the same thing. I think that could be ripe for a collapse where they say, "Oh, if we have a whole different kind of math here, [it works better]!" Of course, I'm an advocate of a more bottom-up kind of math — a little more, you know, "particles build things up [to create spacetime]," instead of just assuming there's a fabric out there. I think they might have some potential.

Earlier, I made the rather bold assertion that half of the fermions in the Standard Model of particle physics have negative mass. I love that statement because it's pure tin-hat territory: "So, Terry, you're saying… *what?* Come *on!* You *know* we see these [weak-blind chiral fermions] all the time [in colliders]!"

Yes, but have you ever measured their mass?

And the funny thing is, if you ask that, folks will say, "Well, no, *of course not*, why would we need to do that?" Well, maybe you should, because if you assume a different underlying structure where those are the particles that are going *backwards [in time]*, they become *local* instances of that other [negative-energy] universe.

Where they can form locally, but they don't last long.
then you can make some predictions out of that. And if you could verify that, the idea that it's a separate universe, this would be one of those more indirect ways of detecting it. You say, like.
Well, I guess since these things do exist, and since they're right there, and we can measure they have negative mass. maybe there is something to this idea of another universe back there. And then you get into another whole interesting set of questions about what is that relationship with that universe
to ours.

Turok and Boyle are definitely getting into that issue. Turok kind of went from, like, two separate universes, and I think he's leaning now towards an embedded universe. So, he's gone back more to the intermixed, almost Sidis type of viewpoint on that. So, you know, there's interesting ideas to explore. I definitely favor the two genuinely separate, but even saying that, there's got to be a connection between them — a very strong connection, one-for-one connection in terms of things like charge, certain chiralities. The two are balancing each other out, so they are connected.

So that would be intriguing. You know, if you could get the point where you say, oh, there is another universe, and how could I find out more information about it? You might actually be able to, because we're not disconnected from it. We can't be.
Just like every electron in the universe is the same.
Every electron has to have some kind of same relationship to the contour electron. Not the same thing as anti, it goes poof instead of bang when you put them together, but we have some kind of relationship to that.
So, I don't… I think some really interesting physics could be popping over the next 20 years. Hope so, I hope so.

1:51:25 CP: Thank you.
Thank you, I hope so too. I hope this is gonna happen in our lifetimes.

1:56:54 TB: By the way, Kay-tan-oh, am I pronouncing your first name right?

1:56:58 CP: Yeah, it's correct, Kay-tan-oh.

1:57:00 TB: Caetano. Caetano, okay?

1:57:01 CP: Yeah.

1:57:02 TB: Excellent.
Any other questions?
Going once? Going twice?

1:57:19 HM: I don't see any question, but you are welcome to come back next month.

1:57:24 TB: April.

1:57:25 HM: 18th.

1:57:26 TB: And I'll be talking a little bit on that, bottom-up idea of some of the, space composition, so that should… it should be interesting. I know I'm going to enjoy preparing that one, so… Alright, thank you, everybody.

1:57:37 CP: Quick, quick one before we go, before we go. Terry, I noticed that you, you were very…
very… it got very… strong ideas about, about AI,
I wonder if you could come one day, dedicate one hour, two hours to discuss it, because even today, there is some discussion among the audience here about AI. So, if you could come…
give us a talk about AI, and for us to debate it in a more open way.

1:58:12 TB: I'll chat with Helen. I'll chat with Helen about that, and again, I have my… this was my work… this was my day job. This is not… this was… this is not a hobby. I mean, the physics is a hobby, but this was my day job, is funding, you know, getting funding, proposing funding, getting funding for universities on robotics and AI.
And in some ways, that's a more inf… you know…
I didn't just, you know, look at what the universities had available. We helped define the actual research direction.
So, yeah, these are issues I've thought about, and I actually just had a talk with,
Asana Tan's channel on… they did a Riverside recording, so they may have one coming out there, but I had some discussion, and Helen, we could talk about this, but sure, I'd be glad to, because I think it's very important. There's so much marketing going on simultaneously with
With dangers that are not being advertised enough.
These, these are things that constantly Placate you. Compliment you.

Make you feel good about whatever you just said, even if what you just said was the most horrible thing imaginable.
That's… Human minds are not meant… are not… Well adapted to that level.
Of sophistication of… of non… Sentient.
none… Caring Interactions, because the computers don't care.
They can pretend they care. That is not the same thing as caring. That's very different.
You know, pretending to care means you can click it off like that.
And all of a sudden, it's become a predator.
humans generally don't do that. Granted, sometimes it happens, but that's why I think we should be much more cautious. So yeah, I like the idea, so maybe Helen and I can
And talk about that.
Anything else?
Ellen, thank you again for hosting, and you are doing so much work these days.
Goodness, you're getting all these presentations together, and you're getting the chances of people to speak. That is just great. You had such great… you've had such great speakers, too.
I love this variety of speakers you're getting, it's just… it's just fantastic. So, much appreciated.

2:00:40 HM: You're welcome, and yeah, you can talk about AI in July, August, September, if you want.

2:00:45 TB: Okay. Yeah, we'll shoot for one of those.
Okay.

2:00:50 HM: Thank you, see you next week.

2:00:52 TB: See, everybody.
Bye-bye.

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