A Sparse-Information Look at the Standard Model of Particle Physics
(Edited Transcript – DRAFT [but close to finished])

Terry Bollinger (Apabistia Press)
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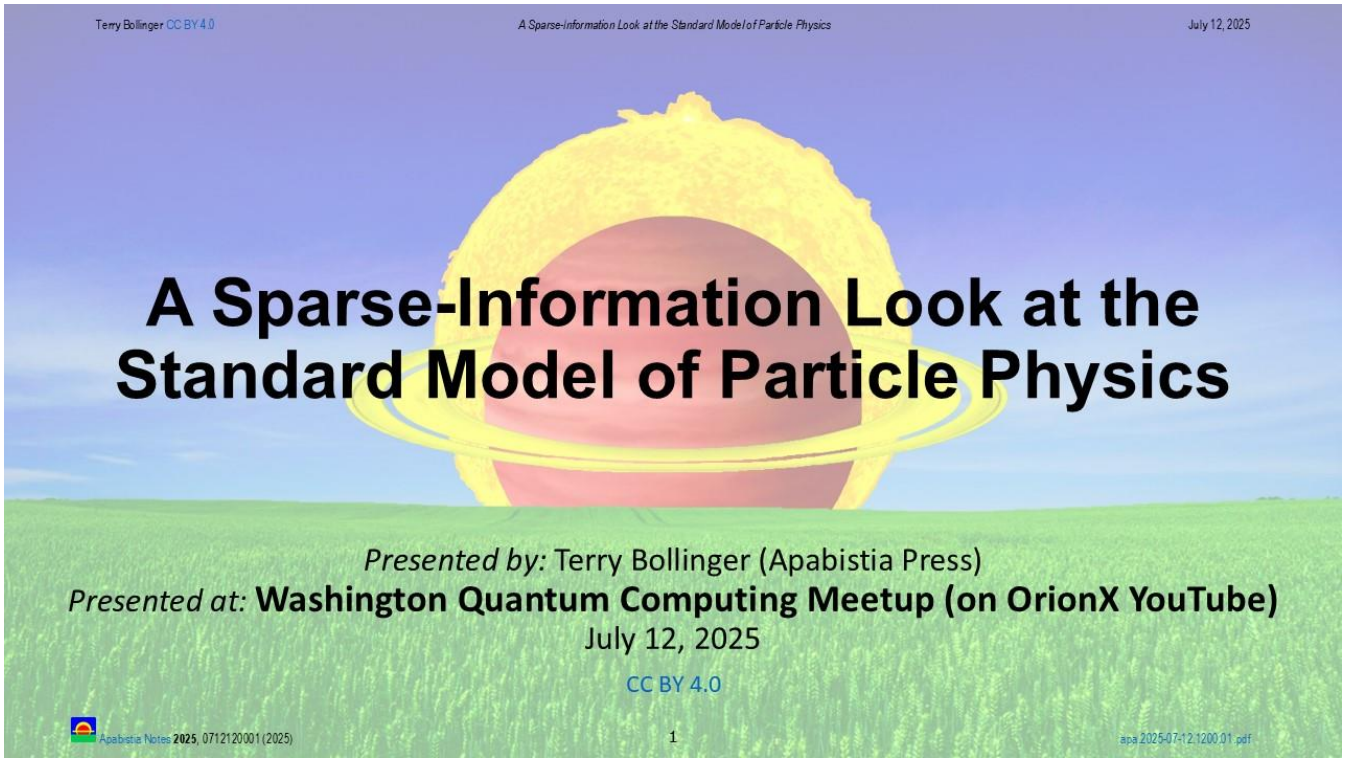


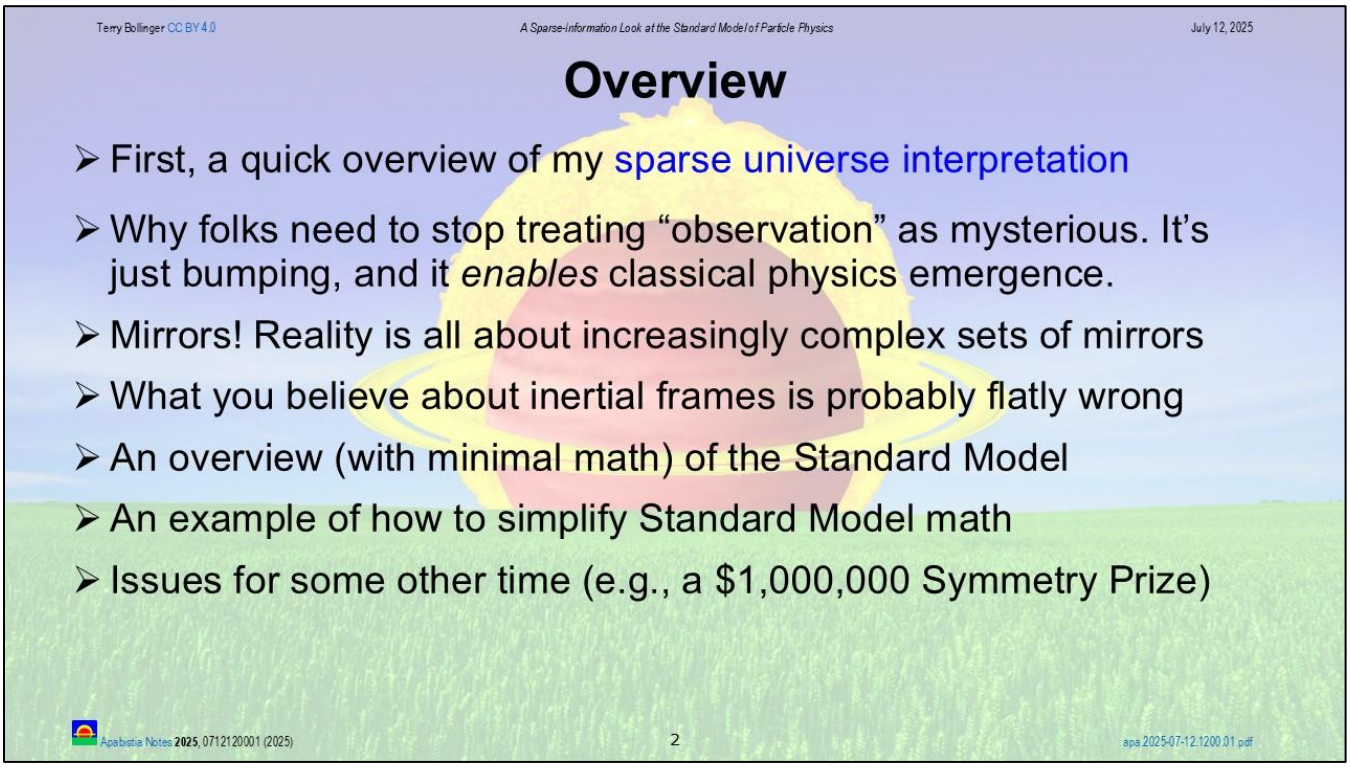
[0:00] Helen Ma (Team OrionX): Hello, everyone! Welcome to our sixth event with Terry. Terry is our computer scientist — and Terry, it's all yours.

[0:08] Okay, thank you, Helen. All right, this is going to be a fairly intensive dive into physics this time, since we're going to the Standard Model of particle physics, which is actually, to me, one of the most *amazing* pieces of scientific work in history. I was very attentive to its formation back during the early and mid-70s, and it was just a *phenomenal* time in physics.

Every week, there were some new findings, some new announcements. This was *solid* physics. These were experiments driving mathematics, driving conceptual innovations, and most of all, driving *prediction*. And that's the most striking thing about the Standard Model of particle physics: it's a complex model. It's not a simple concept, like, in a sense, relativity. [Relativity] is a fairly simple concept. The particle model has to deal with *all* of these different *things* that pop up when you run an accelerator. So [it's] a very complicated bit of physics.

And as I say, I just *love* that period of time. The Standard Model is, to me, one of the supreme achievements of physics. Often, I think, people kind of put it [as] a little bit [of a] secondary story, after general relativity and quantum mechanics. But they're all interrelated, and the particles, of course, are what *make up* reality. That's

where we really get what we *are*. So… and I'm… There we go! For some reason, my page button didn't seem to want to work.



Why the Limbo?

[1:57] In order to talk… Now, [my main] point [is one I've already] made: The Standard Model is a *really good* model of physics. But the idea *here* is to try to look at the issue of, "Why has the Standard Model also been kind of *wrapped in inertia* since it was first found?"

The completion of it was in the late seventies. At that time, there was one particle they predicted that hadn't been found yet, and that's the infamous and notorious Higgs boson, which was found, I believe, in 2012, quite recently… 2017? Somewhere in the 2010s. But that's also frustrating, because it's like: They wrapped it all up, they got all this incredibly good *prediction* out of it. Suddenly, all the *noise* became *patterns*, the patterns became understandable, and people could do things with the predictions about particles.

And then it all stopped! And that's been the status ever since.

They make bigger and bigger accelerators. They look for new things. They propose new things, supersymmetry being one of the most obvious ones that people talk about. None of them has gone anywhere. The Standard Model went, fit with the data, and just nailed it, and then everything since has just kind of withered on the vine, often at great cost, supersymmetry being an example. Enormous amounts of money have been spent on supersymmetry, and the result has been precisely *nothing*. There has been *no* observation that it's actually a correct interpretation of the universe.

The Sparse Information Interpretation

So, I'm starting out with what I call sparse [information] interpretation. This is my own interpretation: I cannot blame anybody else that I know of. I always look for references. So, if I can find earlier versions of the idea, I will always try to post those. But these are my own ideas. So that is a warning ahead of time. This is not something where you go out and find the "sparse universe interpretation" textbook.

So, I'll explain that. And one of the things is some of the aspects of this sparse interpretation.

The Oddly Simple Issue of Quantum Observation

One of the most pointed ones is that I think there are very good arguments for saying that observation is *not* mysterious. It's nothing more than momentum exchange. Linear momentum is *not* quantized, while angular momentum is. And that is why [the distinction is] important: Linear momentum can get *as small as you want*, like one photon bumping against one satellite is a real transfer of momentum, and it's *not* quantized.

And this means that linear momentum can do things that you *cannot do* with the quantum side of quantum mechanics. And that's another mistake! We think that *everything* in quantum mechanics is quantized. No, it isn't! Linear momentum is a very conspicuous example of something that is *not* quantized. Because it's not quantized, it can get so sparse that it goes into the domain of what we call observation, in which you're making such a small impact on the system that you think you're not touching it at all. And it's dangerous to go too far in that direction [of assuming that very gentle touches don't matter] because you *are* still touching it. It's just that you're touching it in an *extraordinarily* gentle fashion.

So, the idea that you need observation at some very high level, [such as a conscious human observer,] is based on the idea that *everything* is a giant wave function. In the sparse universe interpretation, it goes in the *exact opposite direction*. Wave functions are *real*, but they're *small*. It's very *hard* to make them big. So [*non*]-observation — [that is,] keeping a *quantum mechanical* interpretation of a system — becomes a matter of *not* observing it, of *not* bumping into it. You look at the cold temperatures, you look at the situations where quantum mechanics emerges, that's very much what you see. You have to keep *any* kind of impact on the system — any kind of transfer of linear momentum — out of that system.

Symmetries

Now, in terms of the Standard Model, I'm going to be talking about symmetries, because the Standard Model is very much a model of symmetries. But the symmetries have a somewhat easier interpretation, and it starts with the very first use of them. And that's mirrors. If you think of these symmetries as increasingly complex sets of mirrors, you get an idea of why these [symmetry concepts] are so powerful, but without necessarily having to get into a lot of cryptic math and terminology that can throw you off.

Another point that I have to bring out — and this seems like a bit of a tangent, which you'll see as we go through it — I suddenly start talking about special relativity. You'll be, like, "Why? I thought we were talking about *particle* physics."

You *can't* separate the two. The whole idea of inertia frames is an idea that is framed in terms of its *own* set of symmetries, the Poincaré symmetries. This is not even [a problem with any] experimental result. The way people think about how special relativity works is usually *not* in keeping with what we actually observe. Now, different people have different interpretations, but there are some reasons for that, and that has impacts all the way down to the Standard Model.

Interesting Feature of the Standard Model of Particle Physics

I'll talk about the main features of the Standard Model, obviously *very* briefly. This is a one-hour presentation, [and the Standard Model is] not something you can cover in one hour. But you can also show *pieces* of it that are interesting both [in the standard interpretation] and [in interpretations that are] a little bit different.

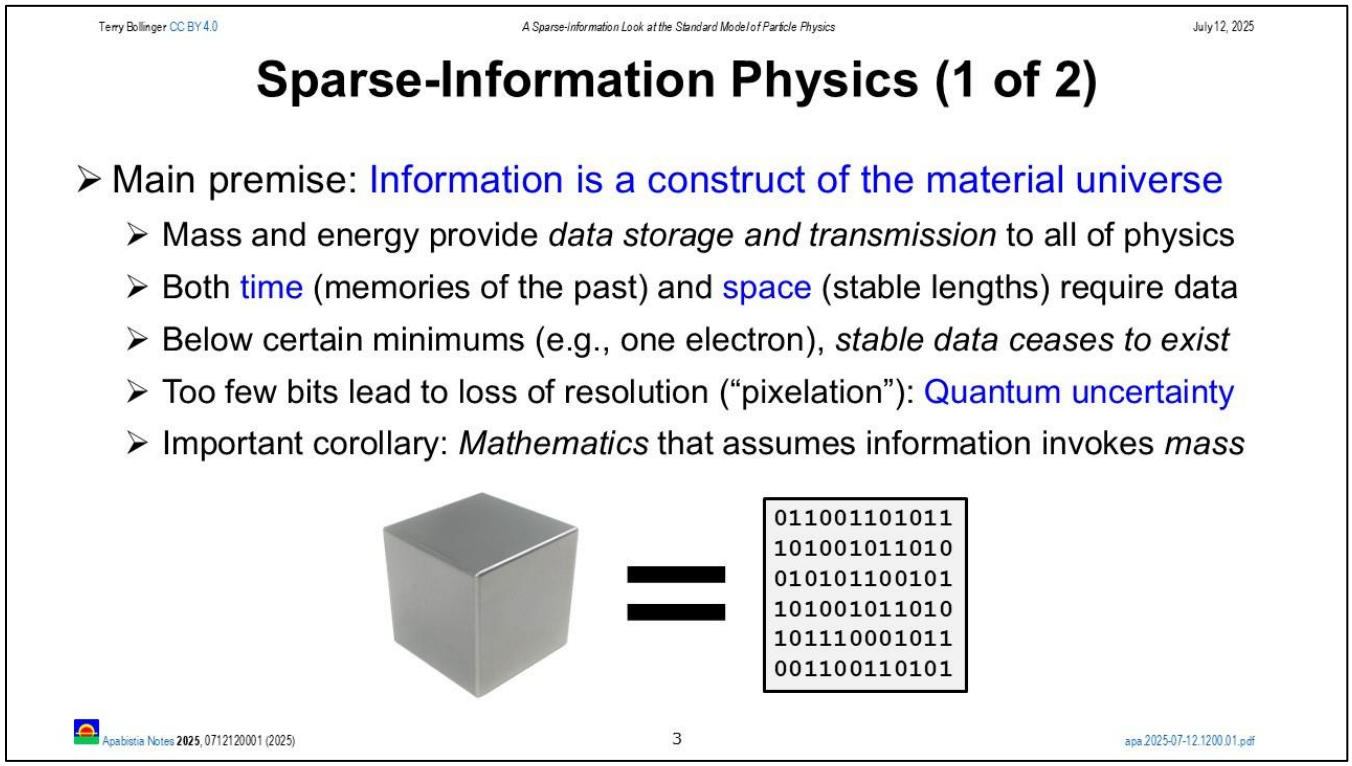
Revisiting Standard Model Maths

I want to talk about options for simplifying Standard Model math.

I would say, with a high level of confidence, that there are some very different, very *simple* interpretations of data. That data is extremely solid, [so] if you do nothing more than refactor how you look at the data — a computer science concept — if you look at the code, and you say, "This code's a mess!", you can then ask, "How do you pick a better set of basis states?" [That] is, of course, a concept shared with physics, and then you come out with a simpler model. That is certainly the case in the Standard Model, that there are some simplifications that are correcting some historical accidents more than they are anything else.

The Millennium Prize Problems

And I have to mention a couple of other issues that I won't get into. And there is that one-million-dollar prize that deals with symmetry, and that symmetry prize is related to some of the issues that I'll be talking about for the Standard Model. So that's the CMI Prize (The Millennium Prize Problems) that was announced back in 2000, and it lies waiting there for someone to get it, along with five other problems.



[8:51] Sparse information physics. What's the idea?

It's a really simple idea. If you have ever worked with information, you know that storing information requires some kind of device. Now you transmit it. You can use photons to transmit it, but if you want to process it, you want to store it. And even in the case of photons, you have to have some kind of energy at least.

So this is an incredibly simple concept. It's that information is a construct of the material universe. Why do I even have to say that? Because it is *very* common to assume — and this dates back to the nineties, in some physics papers — that information is kind of a magical quantity that just appears. In particular, the idea that something called the Planck scale just somehow magically turns into a bit, and some good physicists proposed that, but there is there's *no* basis for that. Not if you're talking about actual information.

Information is an experimental, a real, an engineering concept. It is not something arbitrary. You can't just declare something to be a bit, because it has a nice symmetry or something. So the idea of the surface of a black hole is a

bunch of bits, however appealing that is (and you can make arguments for it), it's not commensurate with what we actually see in any form of experiment.

Now that's important for a very interesting reason. If you talk about time, you talk about memories, because you can't dip into the past. You have to say what happened. I have to have a model of what happened in the past. If you talk about space, you have to talk about stable links. Turns out stable links are very difficult to define (probably impossible to define) if you don't have matter.

Einstein was the first one to notice that. He talked about rulers. He didn't talk about abstractions. He talked about rulers, actual physical objects that require data. So, if space and time both require data in order to exist as we understand it, it implies that space and time have a relationship to matter that is not one of matter just sitting there, and, you know, residing in space-time. It says that the definitions of space and time actually *require* data. You see this, especially in special relativity, where you start playing games with what is space and what is what is time?

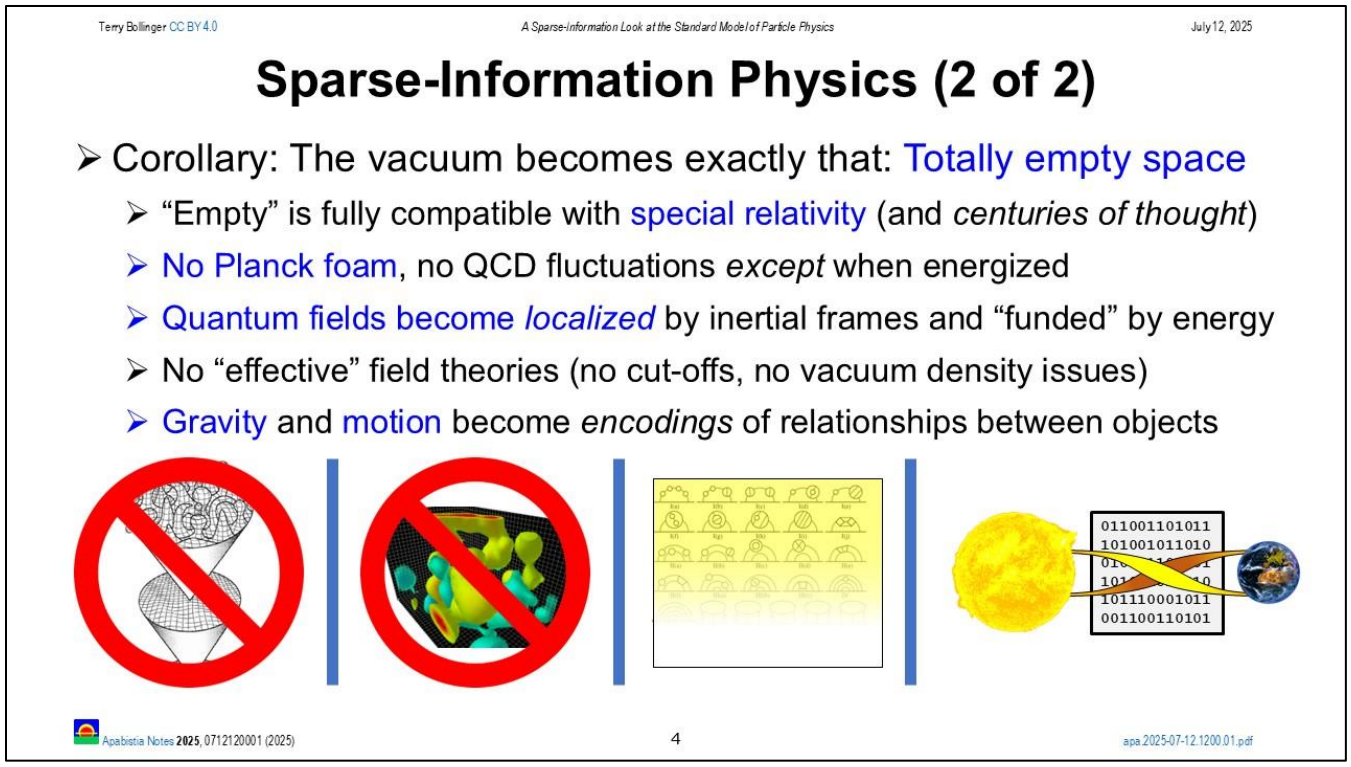
Another interpretation that is definitely *not* common, but I would certainly stand by it: If information is based on mass (on matter) and you go below a certain minimum, say, like one electron, then you no longer have stable data. Now, people talk about one electron being a qubit, but even that's not quite true, because in order for an electron to be a qubit, you have to put it in a magnet, and the magnet has to be big, and the magnet has to be big *enough* that it's not quantum and what you find out is that you actually have to have a rather massive device, compared to an electron (something at least in the atomic scale), before you can really store stable data in that one electron.

There's little subtleties to how information storage works that you have to pay attention to. But, this also points out an interesting relationship: The relationship is that no matter how you look at quantum uncertainty, it's always associated with a lack of information in terms of how much matter. It's well known that matter stores data. That's not new. There's nothing new about that finding. But it's a little bit difficult to believe that the uncertainty of quantum mechanics, and the lack of data in the material part of the system, are unrelated, because they have an essentially one-to-one correlation: insufficient matter, insufficient data — quantum uncertainty. So it just pops up as soon as you get that.

Now the last... and this is a point that... it's difficult if… It's almost something where you feel like you're attacking someone's fundamental beliefs, and that's not my intent, but mathematics assumes information.

If you talk about a Romanian manifold, that manifold is an infinitely precise curvature in some form of spacetime. The moment you say that, you're invoking infinite amounts of information. You may not realize you are. It may seem very simple. It may seem like it's no big deal. It's just an equation. But the equation in its elaboration to make an actual manifold, as opposed to the generative equation, always has to use more and more information, and that information invokes mass. So, what I'm suggesting is that if you take a sparse information view of the universe, you can't separate mathematics from mass and energy… and like wow! You go like: Oh, no, but sure I can. Well, no, be careful, because a lot of the math that we have is actually based on assumptions from the classical era *before* we knew about the limits on going to infinity, on going to very small sizes and ironically enough the Greeks were far more careful about these issues than we have been for the last three or four centuries. They said: "No, if you use infinities, you're going to get off into La-La Land." is essentially how they felt about it.

And at some point we just kind of broke that barrier down and said: "Nope, nope. We can have the infinities we want.". But if you tie mathematics to mass, if you say that the actual meaning of the math has to be connected to the ability to state that as information it makes a difference. That's not just an abstraction. I'm going to be getting into a very specific example of that in special relativity, where you have to be careful about assumptions on how broadly a particular mathematical formula applies.



[15:04] Sparse information corollaries… and this is my favorite.

I remember I was in a meeting once, and I was trying to tell someone in the meeting… (This was not a physics meeting, it was on… Oh, gosh! I don't even remember what. I mean, it's something… you know… it's something more in the range of ontologies.) and I was trying to tell someone that in physics you don't have a concept of empty space. It's not really empty. It's just frothing and foaming and all this. And they were just kind of looking at me, you know, like, what are you talking about? You know, it just violated the premises of how it worked.

And if you take a sparse information view of physics, you actually go back to the idea that *space is just empty*. And the most remarkable thing about saying that space is just empty that makes you instantly compatible with special relativity, as well as centuries of what people thought. Because, special relativity says that everyone who looks at an empty spot space will see the same thing, and I would love to debate somebody on this. If you look at a piece of space, and you say there's a quantum foam there, and you say there's some kind of plank foam, and there's all this… The instant you do that, your math locks into an inertial frame. You've created a special inertial frame. You're no longer special, relativistic. You no longer can say that that frame looks the same from everyone's viewpoints.

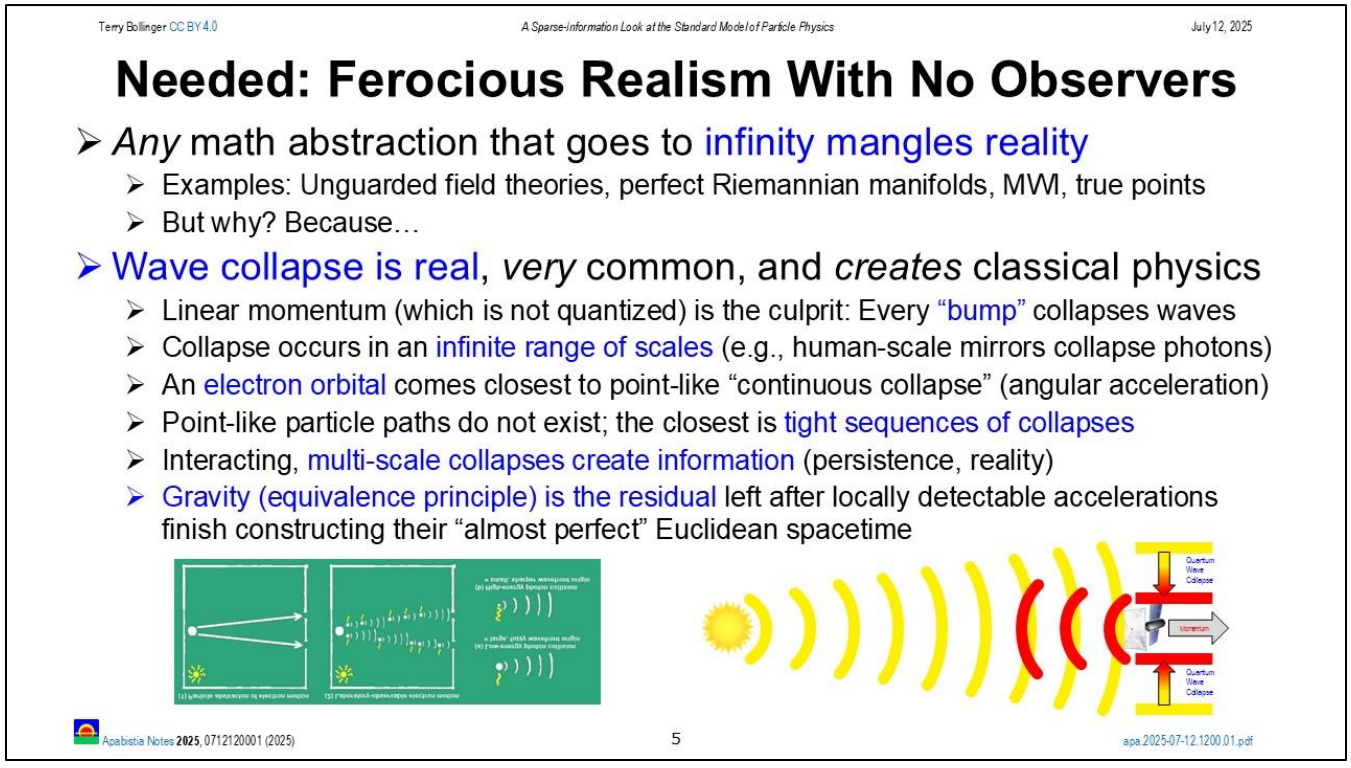
And there's all sorts of tricks that people do to get around this. They have what they call cutoffs, but the cutoffs are also relativistically *not* invariant. And it's just a mess, if you have space actually full of fluctuations and things. So the idea that there's only a finite amount of information in the universe also says that where you don't have matter, you don't have information — not in the sense that we think of it. So you get rid of the Planck foams. You get rid of the QCD fluctuations, except when they're energized by matter. So if you're inside of a proton, you have a lot of energy going around, there's things that can happen.

But in general, you put a severe set of blinders on issues like quantum chromodynamics. You no longer have this frothy foam down at the bottom. You only elaborate to the degree that you have enough energy with that.
The current approach is to use cutoffs. It is to essentially just put a fudge factor in. And you say, "Well, okay, after this point, we don't *care* anymore." and literally, some of the language is phrased that way ("So after this point we don't care."). But, that's a cop out, and I actually wind up going back to a very classical viewpoint.

I love special relativity. I think that it is a deep insight, and it says that empty space should look empty to everyone, not just to one particular viewpoint. So, get the localization, the fundamental energy. No cutoffs. No vacuum density issues that you hear about, because technically these theories predict the universe should either collapse or explode within (I don't know) a few microseconds and the fact that we don't has been considered a deep mystery of physics. Well, only if you have this frothing going on in the background. You don't have that with a sparse information field.

Now, the the most interesting thing, though, is, you have to do something with the issue of how does gravity work and how do things like photons cross through empty space? Because, when we see a photon going through our laboratory, we see a wave. And you say "Well, then, that wave had to travel on something in through the vacuum between galaxies. So how did it get here?". This is the point I think that's most interesting, because, that's where you have to break off and start saying there's something that we don't understand well still, at encoding level, that there are ways that these objects interact directly with each other that then put constraints on how quickly they can interact with each other.

But the interactions themselves are not phrased in terms of space and time. So you have a more like a data relationship theory. That's not as unusual as it sounds. I mean Richard Feynman was one who was famously determined to figure out a point-to-point way of interpreting physics. He didn't want fields. He didn't like fields. Which is ironic, because his theory (QED) has been used to create fields. But he didn't want fields. Not everybody in physics likes the idea of fields filling up space, and Feynman was an example of that.



[19:54] Ontology…

I was asked to give a talk on ontology, and after digging into a little bit, I really like some of the points they were making, which is that you need to be ferociously real about what you actually observe, and that's hard. That's hard. It is really easy to take an abstraction that's very clean, very clear, and then shoot off into infinity with it, and then love what you've done, because it's so simple and it's so pristine. Now, if you do that in computer science, you will get failures every time, because, the simplest case, the beautiful case, the case that you can

handle almost all the data, 99% of the data, is never the correct, fully correct case. It's always the one that fools you with is how pretty it is.

And, it's a very common mistake in programming to take that beautiful case first, forget about the details, and then go down that path. It's not that different in physics. You can take the beautiful little parts of these symmetries and say "Oh, this is so perfect. It's so beautiful." but then you actually apply it to real physics… and you better be careful about the constraints that are imposed by real physics. And this, this sounds like... it *is* a paradox. In physics, people should be more focused than any other group on saying "What does my lab equipment. Tell me?". Einstein was, up to 1911, very focused on just that point: What does my lab equipment tell me, with a real clock, with a real roller? And, we've kind of gotten away from that. Now, I mentioned earlier, wave collapse is real, very common, and creates classical physics. Now how is that for a heretical statement?

People talk about wave collapse like it's some ephemeral thing just only occasionally happens. Blah blah blah! Let me present to the idea that it's the other way around. Any time you have angular acceleration, you have linear acceleration; whatever was a wave collapses. And this happens so often that we don't even think of it as happening at all. So we see an orbital of electron around a proton. We think of that as the quantum situation. And, what I'm suggesting with this is it's actually quite different. We're saying that this is an almost continuously observed quantum situation which forces the non-point-like nature of the electron to pop out, because the electron just says, I'm sorry can't give you any more. This is all I can give you for this energy level. This is the smallest size I can give you and that's it's a small size, but it's not a point.

So, linear momentum (also any kind of bumping, any kind of acceleration) causes these collapses. And, here's just a thought to think about, the classical world that we see where we're always bumping, you know, everything is bumping into each other, condensed matter, the reason it exists, the reason why I have this nice set of regular rules is because of constant collapse of waves. The solid kind of reality we do is an extremely fine scale and continuous (almost continuous) set of collapses at the atomic scale on up. And this is where we get this illusion of part of white papers. The illusion becomes very real at the classical level of our scales, but as farther down you get the tougher it gets.

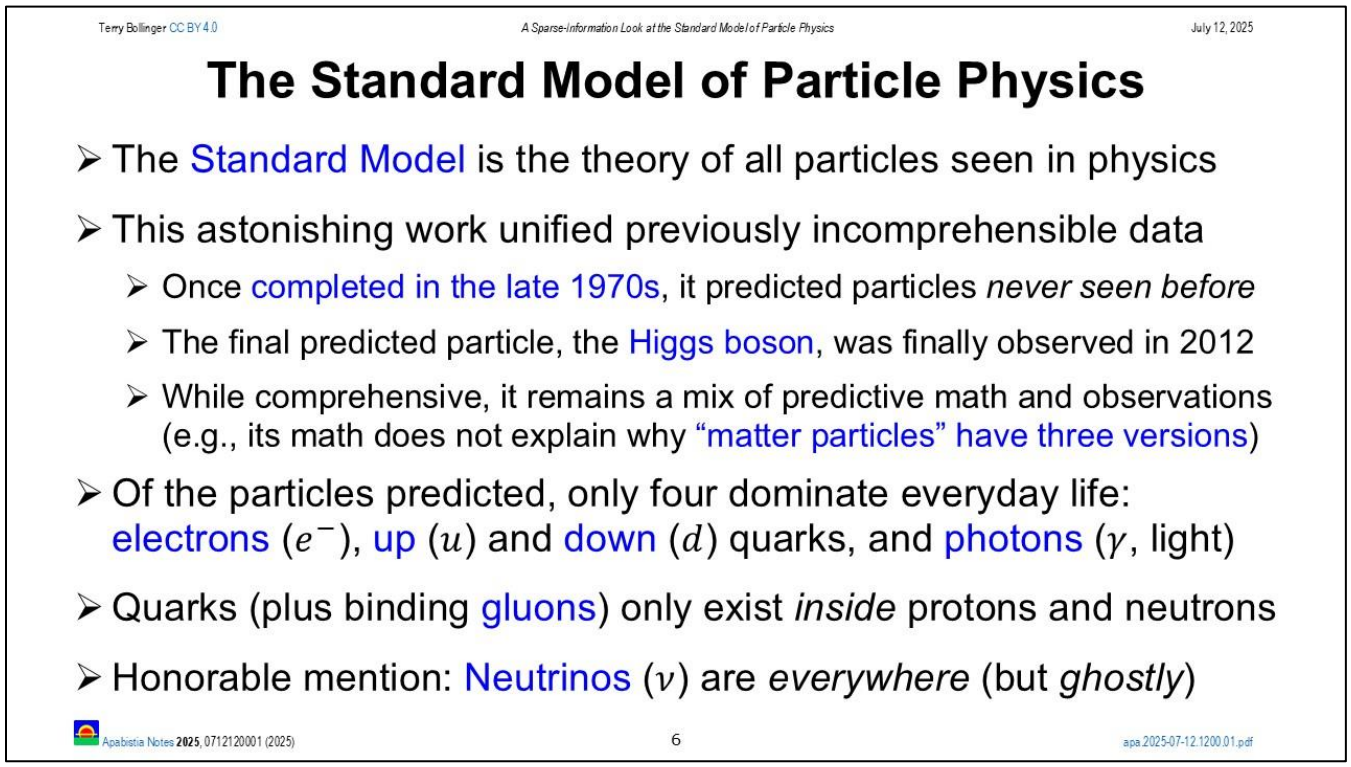
A couple of figures at the bottom… This one on the left in the green box. If you've seen… And almost every YouTube video does this, even by some really good physicists. But they make this mistake. Very occasionally they'll get this right… If you put an electron through a slit and you assume that it's going to keep acting like a particle once it goes through that slit that is just completely wrong. And this is… there's no ambiguity about this. The correct model that you have to use if you're working in physics on that scale is that both particles and electrons *immediately* turn into waves again. Immediately.

You can't keep it as a particle. You can say this wave is now condensed… This one small aperture… It's going through it and from that aperture you can say, you know, it *was* here, but then start spreading again. And, you look at something like a bubble chamber picture, and you say "Well, but there's a particle! it's right there!". Yes, and every single collision with a drop or a bubble is an exchange of momentum and a quantum collapse. And if you make those bubbles sparser and sparser, it becomes more and more wave-like. That is testable. That's not an abstraction. Wave-like phenomena diffract. They reflect. They deposit momentum. And when they deposit momentum you can measure. The waves are in many ways as measurable as the particles are, and that's a misconception. People say that waves, the wave aspect of quantum mechanics in 3-dimensional space, is imaginary. That is just not true.

The experiment on the right… If you look at any kind of a satellite that's being driven, or actually look at any… The pillars of creation is a good example. That is also photon pressure of individual photons bouncing off of small pieces of dust. When you have photons bouncing *as waves*, and reflecting *as waves*, never turning into particles, never atomized (they're never absorbed by an atom), they nonetheless still impart momentum. That's a real thing.

Waves are waves in space, both by particles and by photons. Any kind of particle is not just an abstraction. They have properties. The other thing you notice about this, people think that quantum collapses only happens at the atomic scale. That's also not true. When you get a light, and you look at yourself in a mirror, the light, when it hits that mirror, changes its definition of where it's coming from. And if you do that on a huge scale, like the entire solar system, then a photon is being localized from going out to the entire solar system, that it shows on the right, down to some incredibly tiny mirror. And yet it was never absorbed; it was never turned into a packet of energy.

So that is actually a form of observation just as much as the atomic scale. So again, the message is that there is a huge range at which quantum collapse occurs. It happens all the time. We don't notice it because we're immersed in such a soup of continual collapse, that we call condensed matter, that we don't realize this, this subtle little waving that's going on. I'll throw in one at the end there: gravity (equivalence principle). There's a whole different way of going after gravity. Instead of a force, that's what's left after you get rid of all these observations. You know, all these observations create the illusion of a space, of a completely infinite space. But if the space is being created by matter it has limits, and the fringe of those limits, at the point of detectable accelerations, there are no more detectable accelerations. That's the equivalence principle of relativity. Then your idea of a perfect Euclidean spacetime starts to fail. Now this is just like a starting point, but I think it's a starting point that gives you a better handle on how gravity relates to a universe in which space and time are themselves information constructs of matter.



[27:46] Standard Model particle physics... Enough for the sparse interpretation.

Fantastic model! I love it… I've already said about how it was 2012… That's when it was… 2017, 2012… when they finally found the Higgs boson. And Higgs himself never, ever thought they would detect that thing, because there's an enormous amount of energy involved. So, it wrapped it up. and the most disappointing thing, I think, for a lot of physicists… I know I was disappointed. I kept hoping. I said maybe the Higgs boson will just turn out to be something, you know, totally unexpected. It didn't. It was kind of boring, and it all just came out and said, "Well, yeah, okay, you know, it worked again. The Standard Model worked once again.".

Little insight: You've heard of superstring theory? You want to know where superstring theory really originated? It's really simple. You got, in about 1980, you had universities full of physicists who had been working in this fantastic Standard Model, with all this fantastic math, and they had nothing to do. And they were pretty explicit at the time; they talked about this. Well, maybe this string theory stuff will give us something to work on, so you can get into the details about the string theory and how it emerged, which is a fascinating story by itself. But the truth is literally, people had nothing to do. And they openly talked about having nothing to do, and said, well, this string theory, boy, there's a lot of math in that. Can't predict anything with it, but we can sure do a lot of math, and that's what happened. You've got decades, decades of math, all of which was been mostly disconnected from experimental concern. The few experiments that have tested it have said it's not possible, by the way, that's been done with high energy gamma rays.

Now, in the Standard Model, you've got a lot of particles. I'm not about to go through a bunch of them, but only a few of them really count for us. Got these electrons. We all know that. Electricity. You got up and down quarks. You say, well, where are those? I don't see those every day. Yeah, you do. But they are the parts that give you massive atoms. They're the not new parts… The particles that in triplets make up neutrons and protons. Always in triplets, by the way. They can also do it in pairs. They can form in pairs, but the parts that we see are the triplets. One triplet of those forms, the neutron, the other triplet forms the proton, and there's a whole huge family of other things that you can do with those, *but* those are the main ones. And of course you have photons. You have light, and light is the main interaction at massive scales, at spatial scales, between these. Now, quarks also have a kind of particle called gluons that only exist inside of protons and neutrons. So they don't, they don't go very far, but they're important. The total mass of a proton or neutron is mostly from these very energetic gluons, sticking those little fairly light up and down quarks together. So it comes out to be about a third of the mass of a proton or a neutron, from the number of muons that are generated by these quarks. So they're like photons. In fact, they're a lot like photons, but with some really quirky differences.

Final one we have (honorable mention): neutrinos. You are being bombarded by neutrinos. They're all over the place. They're going through you right now in enormous numbers. They go straight through the earth and come through you anyway, because they all stop at almost nothing. They have a nice little symbol, called *nu*, which looks exactly like a v, which causes no end of confusion, but it's the Greek letter *nu*, and one little historical side note on neutrinos: Those were supposedly how Superman got his powers from the yellow sun. You know, so the neutrinos could go everything, and occasionally it was funny… I guess somebody in the old Superman comics got into physics enough to say that, hey, these things are… These are cool. These explain where he gets his power from, and there are a lot of them. They come from the center of our sun, mostly.

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The Role of Symmetries in Reality

- Particle physics (and reality) is like a delightfully complicated house of mirrors
- Hierarchies of reflections create the complex universe we think of as "classical" physics
- As long as images co-reside in the same local spacetime, they remain *equally* real
- Dirac was the first to use symmetries to predict a new particle: the *positron*
- Strange, hard-to-cancel combinations of images create persistent paradoxes: time
- Hydrogen atoms are one such paradox

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[32:02] Symmetries!…

If you look at part of Standard Model physics… And this is where, if you want to put something like… to get a little attachment point and say, "Oh, I can't understand all this stuff… all these… all these weird names and acronyms, and all that."… You *can*, because if you just think of what mirrors do. You think of a mirror, how it makes an image, and then makes another image, and first thing you know, you have this complicated trio, or this complicated hexagon, some complicated shape, all of which are reflections of the single original object. Well, how do you classify all those reflections? Most of the math of quantum… of physics in the area of the Standard Model, is about mapping mirrors: saying, "Okay, we have this little thing. We think there's another image of that.". How does that image behave? What kind of an image do I have of? Is the image like a rotation? Is it a flip? Is it a reflection? Is it some other stranger form of mirror that does something else to it? But it still boils down to mirrors.

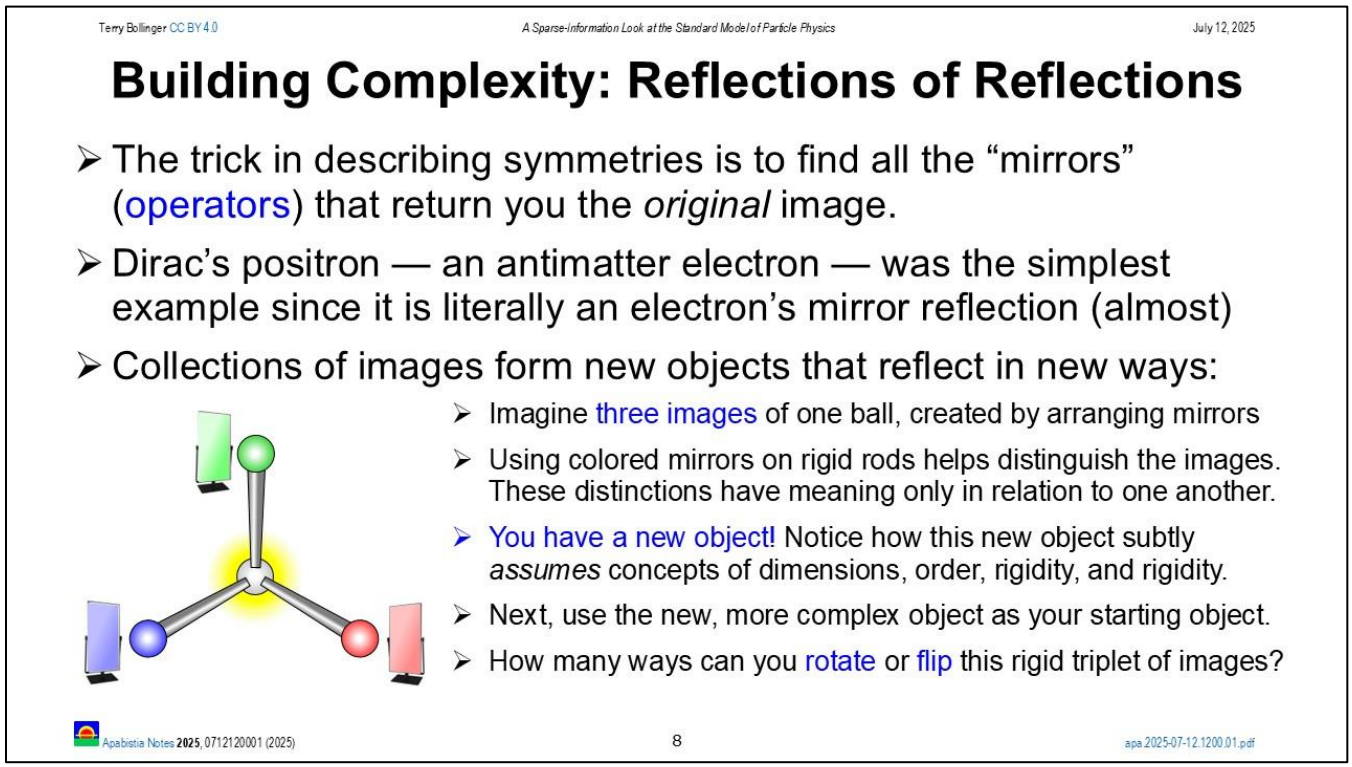
The first and most conspicuous example… I love this one because it is so simple… If you look in many physics textbooks, they'll tell you that the mirror image that you see, as just looking in a mirror… if that was real, it would be antimatter. And the reason for that is because that's how Dirac first found this particle called a positron. He literally took a mirror reflection of electron, mathematically, but it was still a mirror, and looked at the properties and the properties turned out that it reversed the charge and did some other strange things to it. But he didn't even believe his own prediction. He thought he thought he made a mistake, but that was the first use of symmetry, and it was about as literal of a mirror image as you get.

Now there is a little twist to that. It's not actually exactly a mirror image. There's there's a thing in matter where every one of your particles is actually two particles, not one. And, if you go through the full argument about the two particles, and how they switch back and forth via the Higgs boson, then you find out it's a little more complicated than that. It's not a perfect symmetry. But antimatter is very, very close to it, and that's so that you could imagine an antimatter universe that would be quite viable, that would actually work fine.

Now, this is a tearing point in this: What I would suggest is that one of the reasons why we exist at all is that if you start combining mirrors in complicated enough fashion, you get to the point where you can't get back out of

it. It becomes too complicated to fall apart. You wind up with paradoxes. So this set of images gets matched against this set of images, and then they don't combine well anymore. Hydrogen atoms, mundane hydrogen atoms. So you think what's the big deal about hydrogen atoms? Surely it's not exotic. Hydrogen atoms are bizarre because the symmetry should have been an electron in that positron. And if you put an electron and a positron together, they just annihilate each other. They just go *bloop*, you know, and it's actually it is actually considered an element. It's called positronium. But positronium does not last. So, the paradox is that the hydrogen atoms manage to achieve exactly the same positive charge, but they squirrel it away into a different, much more complicated form, using those quarks. But it's still the same charge. So it's a distorted mirror image, and then they wind up bumping into each other, but then they can't fully cancel. So, they just kind of settle in and say, "All right, it's the best I can do."… This tiny little point-like thing (literally point-like thing) in the most meaningful sense of it… So you got a tiny little dot there, and it then it stuck.

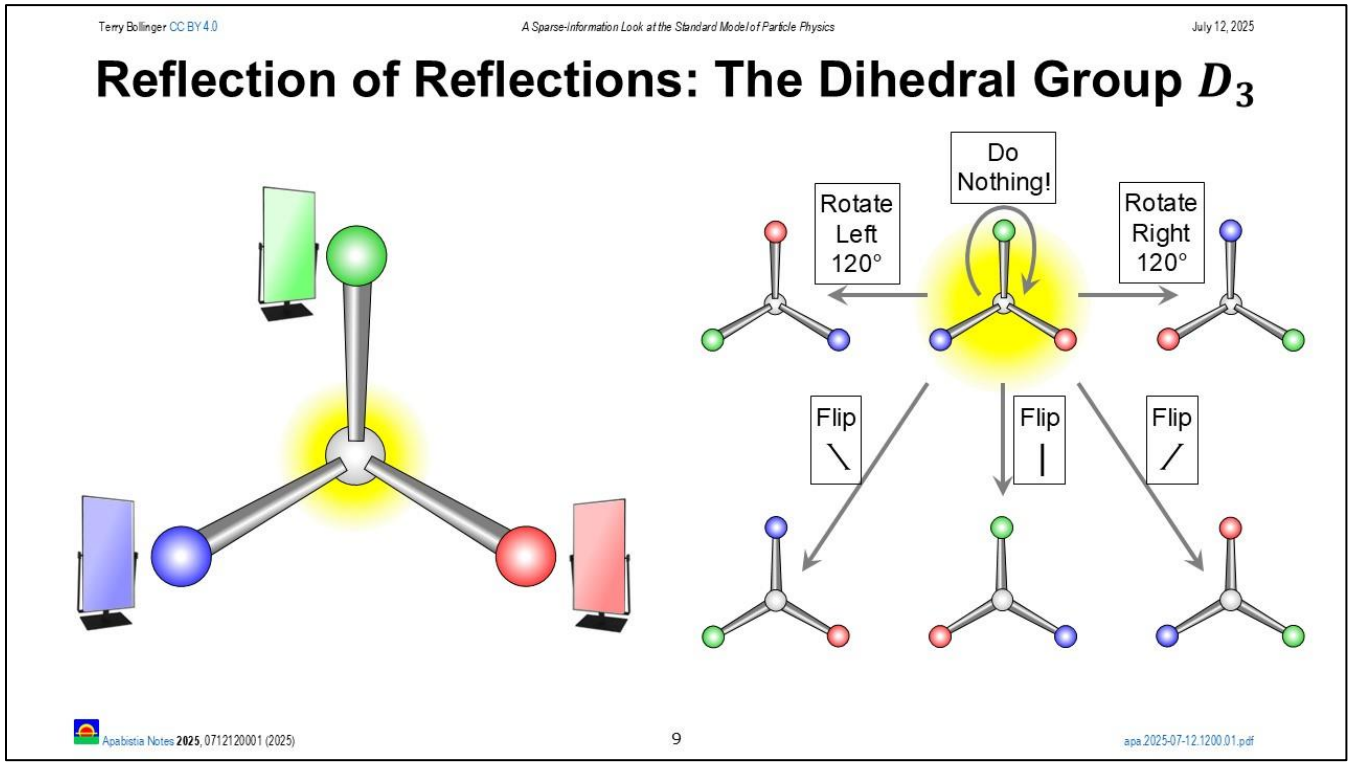
Now that sounds trivial, but until something in the universe gets *stuck* in that fashion and can no longer cancel itself out, you don't have time. Time is meaningless without the ability of something to just sit there and *not* do anything, which is exactly what a hydrogen atom does. It's the simplest case of something that sits there and doesn't do anything. It doesn't decay. It doesn't break down. It doesn't convert to something else. It doesn't go skittering across the universe like a neutrino. It doesn't have a massive charge that causes it to slam into something else like an electron by itself does. But the almost cancellation of the electron and the positron, and even almost nothing, except gravity, is where you get this idea of a *meaningful* definition of time



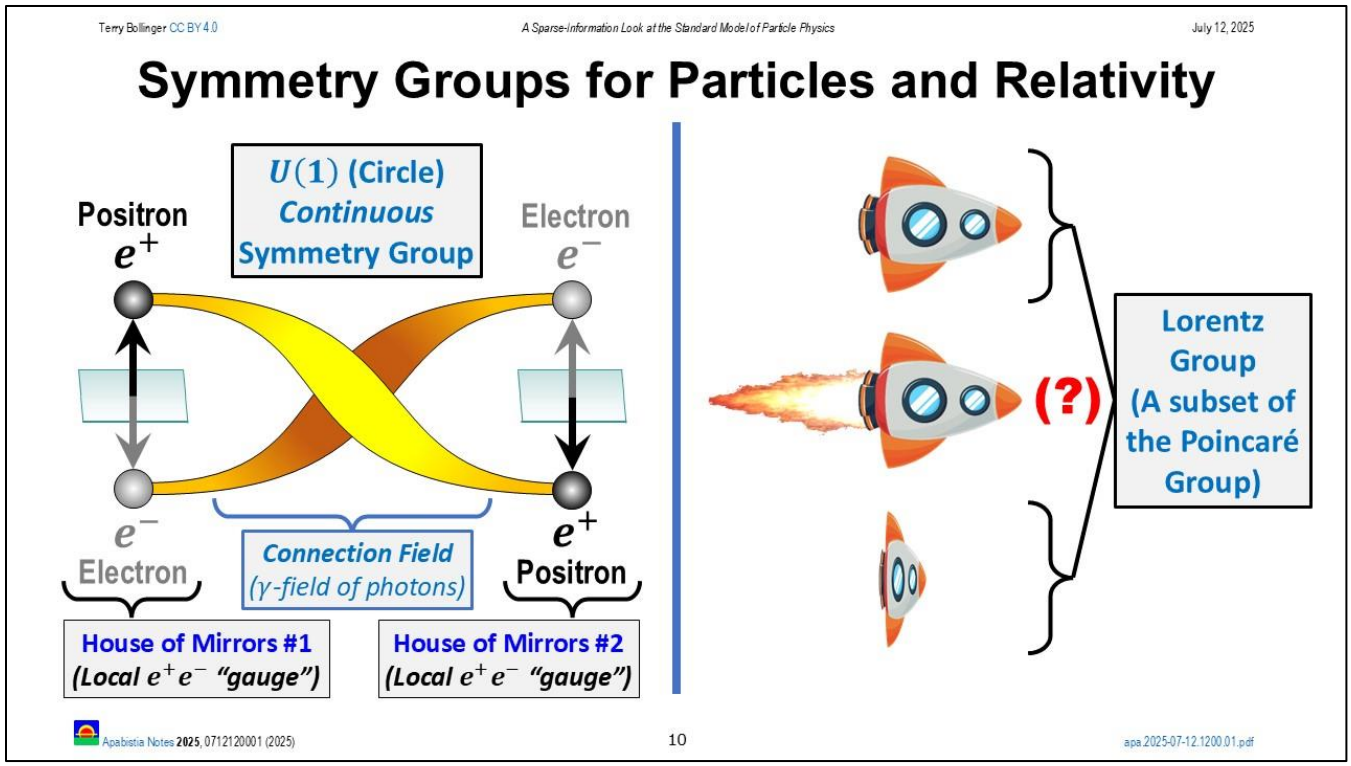
[36:44] Complexity from reflections…

So, I'm going to give a specific example of what I mean by reflections. Imagine you have one ball and you have three mirrors, and just completely arbitrarily you colored the mirrors, red, green, and blue. Just something, you know, you add, so they filter the light a little bit, so the images are distinguishable from each other. The result of this is, you wind up with a new object. Now notice, it still has its roots back in that original object. The original object is, in a sense, still there, but you're seeing pieces of it, and you're seeing a piece of it with different relationships.

Now, the other thing, it's kind of a warning… This is why you have to be careful in math… The instant you do this you're assuming all sorts of classical, space-like assumptions. Remember what I was saying earlier about space. Space doesn't really exist without information. So there are some assumptions in this. The idea that these things can have a three-way relationship to each other is a fairly remarkable assumption. But, if you do assume it, then you say it, you create a new object. So, to look at the whole mirror image again, this means that "Oh! Now I can do some new kinds of reflections. I can do new things that wind up to have even *more* complicated results!".



[37:59] And these are very well known in math. Something called the Dihedral Group, D2… D3! I'm sorry… And it just says, what are the ways that I can take a triplet like this, a triangle, three points, and convert them so that I wind up having, essentially, how do you undo the mirror so you can get back to the original object? So ,if you have this rotate left from that, if you invert that, you go back to the original object. So each of these has an inverse where you go back and allows you to go to the original object again. And there's a finite number of these operations that you can do on this triplet. You can do nothing. That's a valid operation. You can rotate it left. You can rotate it right. You can flip it over three different axes, and those three different axes will give you three different three different results. So if you look at all six of these, they're all unique. There are certain ways of rearranging those reflections, so that you have a new level of complexity with that. So, this is a cool feature of how do you track these different nerve reflections? And it turns out to be very relevant to physics.



[39:09] Now, here's where I go into that little tangent that I warned you about. Relativity also has symmetry groups, *because* you can't… Well, let me get the one on the left first… One of the simplest symmetry groups… Here's where I start to get into the actual Standard Model, but then I'm going to back off and go off into relativity for a bit… The simplest one is called U(1), and it really is just a circle. It's really just a rotation. And, the way it works is just like I was saying, there are different ways you can flip those concepts before about the trio of colors.

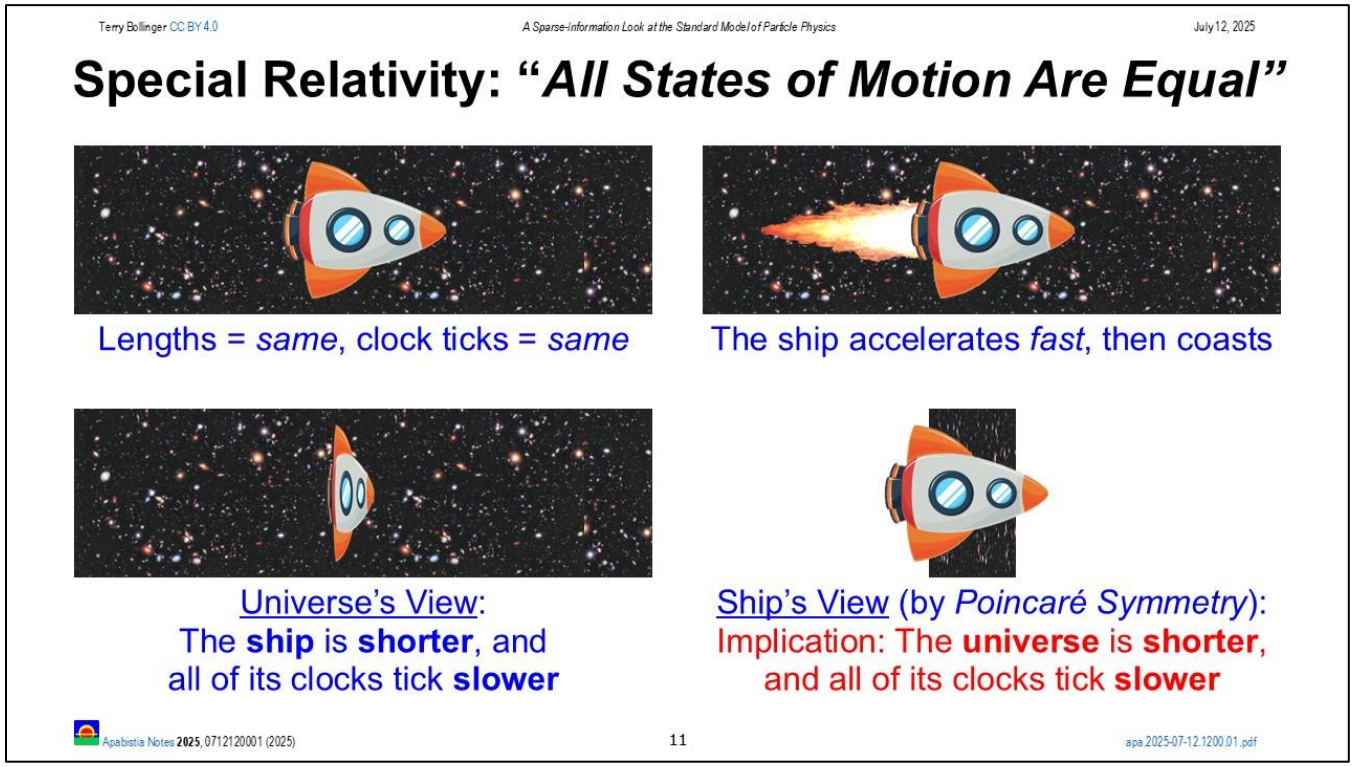
Here's an even simpler one! You can have a polarization, just like on a battery. You have your positive terminal, you have your negative terminal; which are represented by two actual particles. And you say, locally, "Okay, I'm sitting over here in my little spot in space. I got my little place, you know. I'm minding my own business, and I can have those things arranged however I want to. But then you can say, "Well, somebody else over here in some other region of space, can have their own definition of up and down, or, you know, which way those things pointed."… Is the electron on bottom? Is the electron on top? And thi[39:09]s creates a little mathematical issue, says "Well, but how do I reconcile those two?"… And idea that's going on is something called a gauge symmetry, and you kind of forget the word gauge. The gauge has a weird history. It's really just a history of how do I undo a certain set of mirror reflections? If I have different definitions of those mirror reflections in different spaces, how do I reconcile those?

You wind up with an idea of a rotation or an operation called the connection field, and that connection field turns out to be the source of photons. So if you hear that people talking about virtual photons and how they work between these charges, they're really referring to this this strange mirror relationship, that you have these two particles, e^+ and e^- that just *are*. They've been created by lower levels of reflections and permutations and symmetries, but then they have local definitions that can change. And, the remarkable thing is that nothing more than like winding the spring or unwinding the spring that connects those definitions is where you get the energized field that forms photons. So if you… this is intended to look a little bit like a spring that's been coiled, because that's pretty much where it how it operates.

So, one of the simplest groups of the Standard Model, then, is the U(1) (so one of the first groups identified), and it tells you how to create photons. So you wind up getting three particles out of this. You have the electron, you have the positron, then you also have this connection field, which emerges from what they call gauge theory. So

when people talk about a gauge theory think in terms of connections like this. You say "No, I've got a local symmetry there and a local symmetry there, and, the space lets them have different properties, different definitions. They say, "Well, and then how do I put those back together?"… So you wind up with these these connection fields and this idea of the gauge theory.

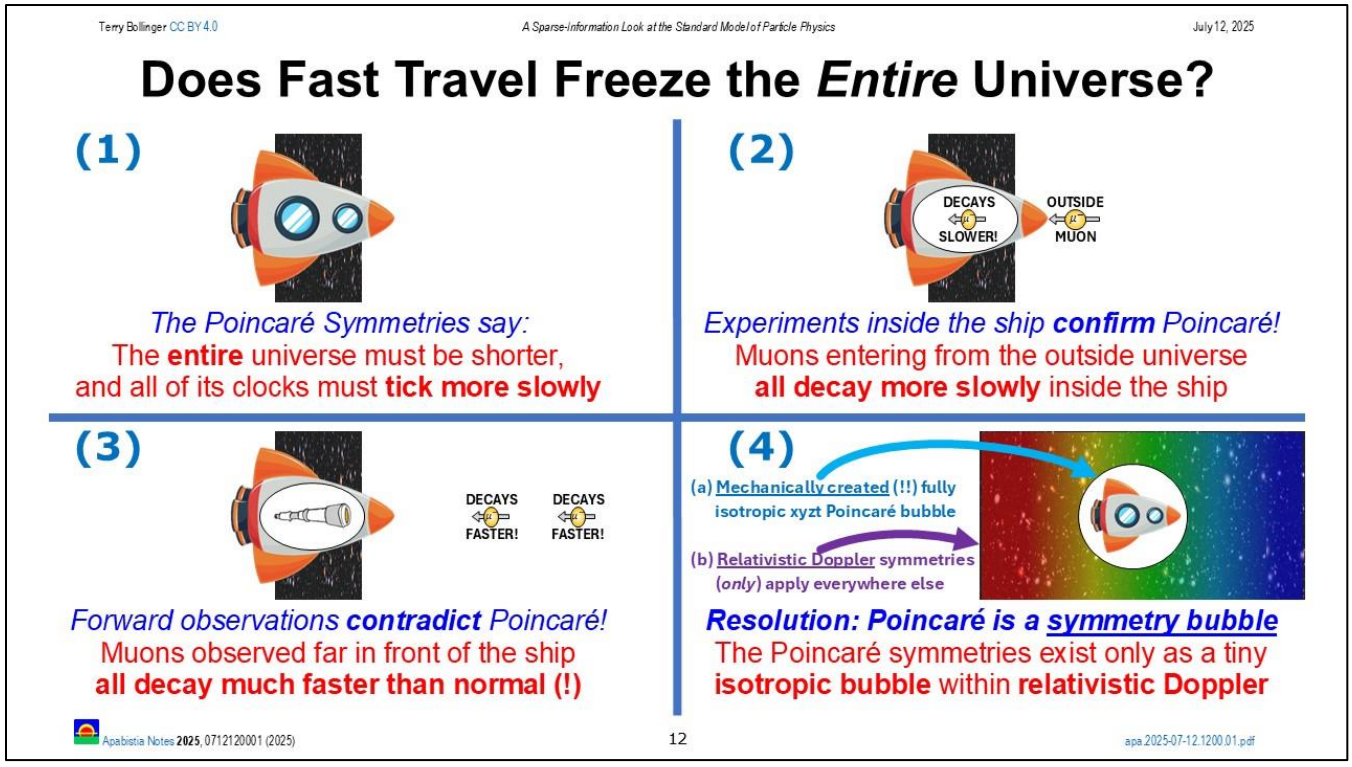
Now, another set of continuous… Now notice that was continuous, too, because obviously a circle… If you rotate a circle, every time you rotate it's like a whole bunch of little tiny mirrors infinitely close together. So, continuous symmetries are an important thing, too, especially in physics. One set of continuous symmetries are the Lorentz group, which is a subset of the Poincaré group and special relativity… Beautiful group! It covers how you can make things move, how you can rotate them, how you can translate them, and it leads to the strange effects, such as shrinking the length of a spaceship after it goes to a very high velocity. Don't ever think that is an arbitrary shrinkage. That's not just a shrinkage in viewpoint. That is a very real shrinkage. There are different kind of experiments you can do in which they talk about the Barne experiment. People get too company in the explanation. The contraction's real. If you look at this thing as it goes by from your viewpoint, it is going to have a very short length. And, you can do all sorts of experiments to verify that. You can instrument the bejeebers out of it, so you have all sorts of data that you can collect, and it all comes up to the same conclusion: This thing's short. It somehow got short. So that's the Lorentz group.



[43:38] There is a problem with this issue. And, ask yourself this as I go through this slide, because I'm always curious how people react to this. The Poincaré symmetries, or the Lorentz subset, say that if you accelerate a spaceship, and allow it to coast, it becomes… Two things happen to it: It becomes severely contracted in length. We're talking about really high velocity, something like 99, you know… say, 95% of the speed of light. So it becomes contracted (and I say, in a very real sense; this is not some arbitrary contraction) and it also becomes slower in time. Now, the beautiful thing about special relativity, and the remarkable insight that Einstein had of this, was that the view from inside that spaceship is *exactly* the same.

If you're inside a spaceship, and you do experiments, and you do different experiments in different directions, you cannot tell that you're moving. All the velocity of light's the same, particles decay at the same rate, everything is exactly the same. So that's called a Poincaré symmetry. And people say then, "Oh! So this is exactly

symmetric.”… Now, here’s the question though, does that mean that when you go to a very high speed in a spaceship, that the universe is suddenly enormously shorter, and all of its clocks now ticks more slowly? And, I can name you any number of textbooks which essentially say that that’s what happens… So I don’t… I don’t know which particular textbook you’ve read. And then everybody goes into kind of a paradox mode, they say “Well, wait a minute… How does that work?”… You know, it doesn’t seem quite right. Because, how can, you know, for instance… Does that mean you can travel from one end of the universe to the other, and you’ll get there essentially instantaneously, because the universe was frozen in time because you were moving so fast. That’s a real consideration, because if the Poincaré symmetries are exact, that’s what should happen. You should say that I can freeze the entire universe by doing nothing more than going at a very high speed. And you say the length, and I go through it quickly, and everything will be the same. Is that true?



[46:03] Well, no. It’s not! It’s experimentally not true. It is absolutely false. It is so false that if the people who made GPS satellites did not use the actual equations for how this works, which are not the Poincaré symmetries alone, you would crash your car every time you tried to use a GPS. It would tell you all sorts of bizarre things. It doesn’t work that way. Here’s how it does work: If you are inside that spaceship and you’ve gone through enormous acceleration… Section 2… A muon comes in, goes into your spaceship. You say “Okay. If the Poincaré symmetries hold, then that muon should decay very slowly, because it’s moving fast. You will find you’re exactly correct.

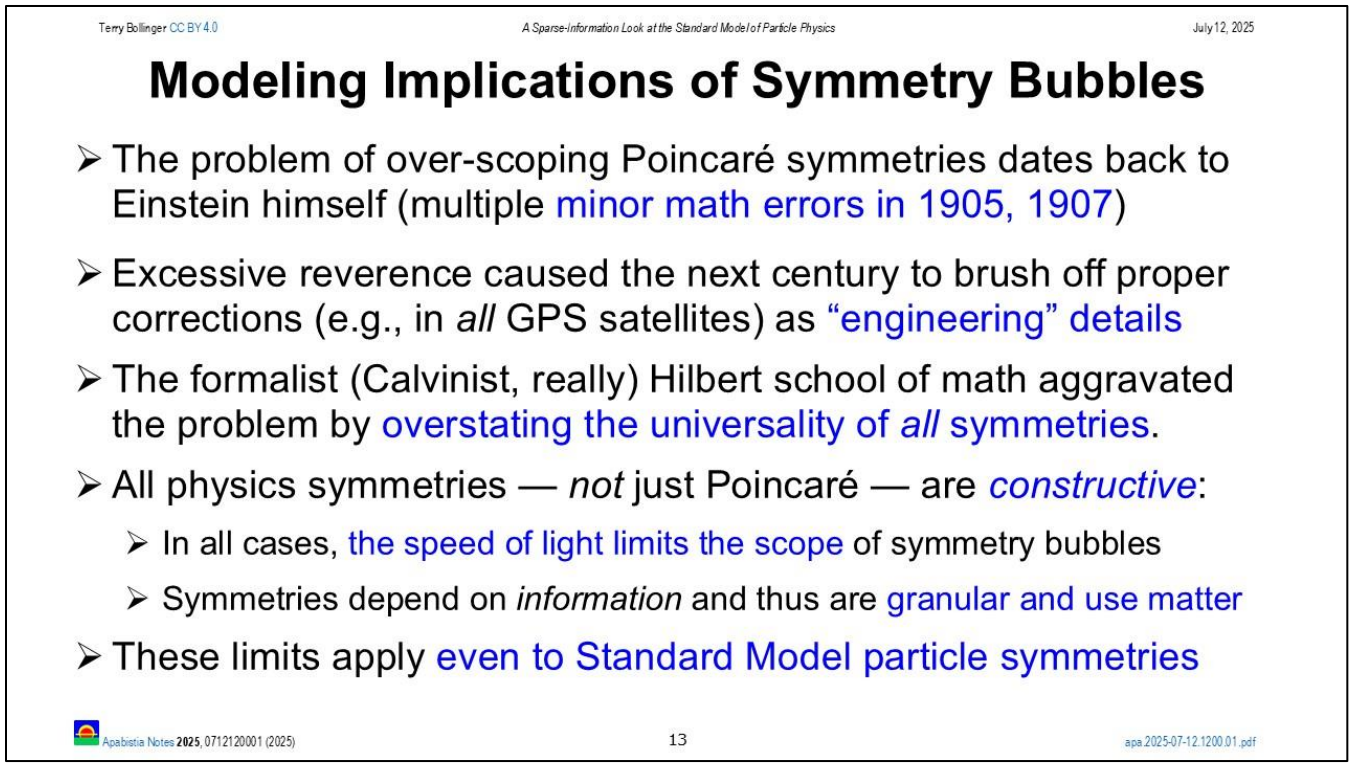
[47:46] That muon inside of your spaceship goes slower. You then extrapolate and say “Well, if the *muon* is going slower, if the *muon* is decaying slower, then the entire universe *surely* must be moving slower.”… And that’s wrong. And then this is… it’s not just a little wrong; it’s totally wrong. If you instead take a telescope and look ahead, look in front of you, you’ll see blue-shifted muons, you’ll see blue shifted particles. What’s a blue shift? A blue shift is speeding up the clock, because light is a clock: the faster it goes, the bluer it gets. And, people kind of go through interesting little mind games to kind of ignore that and say “Well, it’s just an optical effect.”… No, it’s *not* an optical effect. If you look in front of you in that spaceship, what you will see is things decaying faster, things changing faster. You’ll see time flowing faster, *not* slower, faster. And you don’t hear that in the naive versions of how the symmetry of special relativity works. You’ll only hear about the case two of inside a spaceship. If you look to the real case, of saying *look outside*, that’s not what you get.

There's another set of symmetries. These are called the relativistic Doppler symmetries. What *actually* happens… And this is… like I said… if you're doing a GPS satellite, you *have* to do it this way. So this is not unknown information. It's just… that's just engineering. So no, you do have to worry about that. This is physics. If you look, what really goes on is the spaceship is a bubble. It's an isotropic bubble. It's the same in all directions, because you made it the same in all directions. You had to actually change its length. You had to actually change its clocks. You had to do a number of transformations before you could get that spaceship tip top and ready, to go to have the exact Poincaré asymmetries that you wanted.

Einstein was aware of this. Einstein talked about this in his 1911 paper, about how you have to reset the clocks, and you have to do these different transformations. So this not… This is old too… This is *not* new. What Einstein *didn't* do was go beyond that bubble. And if you go beyond the bubble, then you see this blue shift in front, you see time flowing faster, you see time dilated behind you. So why does it change? Why doesn't the Poincaré bubble extend outwards? Because the Poincaré bubble requires mechanical changes to the system.

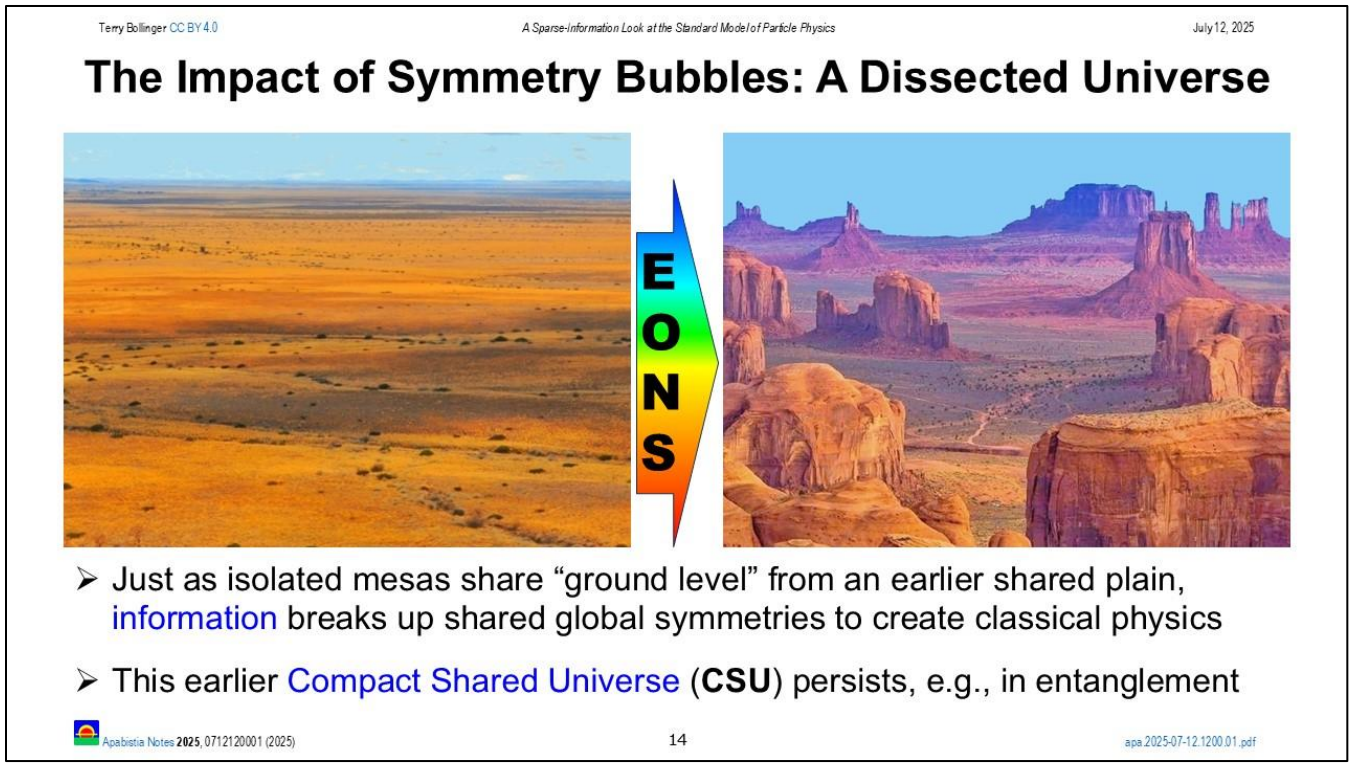
This was… There's… I've got a list of four quote "minor" little bugs or math errors that Einstein had in these 1907, 1911, 1905 papers and this is one of them. He assumed that you have no physical transformation. It's just not true. And it's not hard to demonstrate cases, especially with satellites, where it's not true. You have to physically move satellites closer together to create the Poincaré bubble. And that's a mechanical transformation. And Einstein… even he… yeah, I love this… He has this little footnote, he says "These equations are true only if there's no mechanical transformation in the system."… Somewhere in his mind he *knew* there's a problem, and I can't tell you why he knew there's a problem, but he knew there was a problem, and he couldn't resist putting a footnote and saying "Well, it is based on this assumption."… but he never quite grabbed hold of what that difference was. As we got into things like stellar jets.(these galaxy galactic jets that go at very high velocities) people were forced to deal with some of these issues on the astronomical scale. But the relativistic Doppler… that's where that's where you first saw the occurrences of this relativistic Doppler equation. But it's still people do interpret it. They just kind of skip over the fact that it actually changes the set of symmetries involved.

The bottom line of all this is that the real symmetries that apply, for point three asymmetry, are bubbles, and they're bubbles that require *matter*, and the matter is a confined set. You either applied it… You either joined the crew… You either joined into the bubble or you did not, and it takes time to join the bubble. You don't erase the past when you join the bubble. You don't change the rest of the universe. Now, why? Why the relativistic Doppler? Because the relativistic Doppler is an *interpretation*. It does *not* require the rest of the universe to change. Relativistic Doppler, unlike Poincaré symmetry *is* applicable to the entire universe. It *does* tell you how to observe the rest of the universe, but you don't have to *change* the rest of the universe. Important difference. So an observational difference versus the actual change… So, again, it just may undo some of your definitions of how some of these symmetries work; you have to be careful with overextending symmetries.



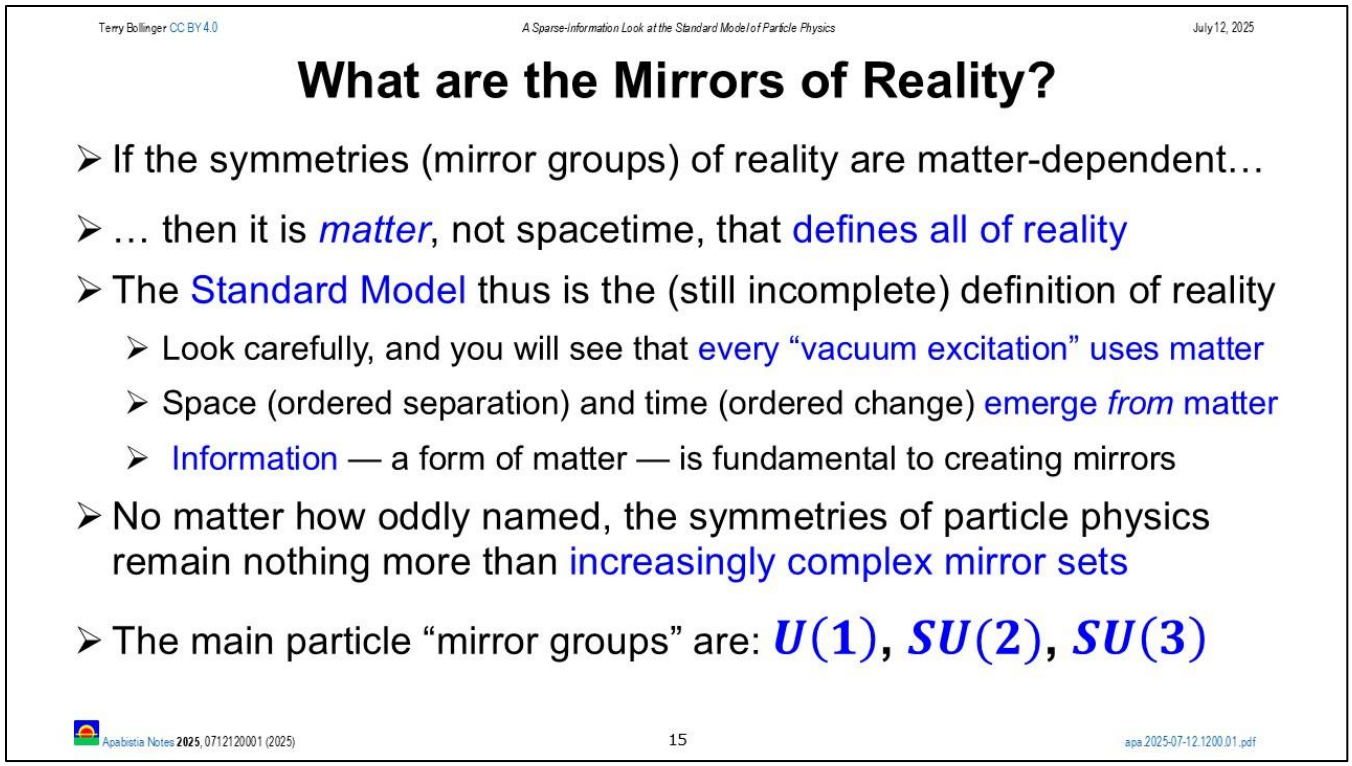
[51:52] I mentioned the minor [indecipherable audio] GPS satellites… Overstating the universality of symmetries is a *really* risky proposition in physics. If you don't recognize that some of these things are very finite and very constricted and very limited like that, like the Poincaré bubbles, then you wind up with a view of reality that is unrealistic and also winds up freezing solid. Because that's where you… That's why Einstein got into this whole thing about a block universe like this… Because if you extend every one of those Poincaré symmetries out infinitely, what you really wind up with is an unsolvable mess. But the *seeming* solution is just to freeze everything, say "Oh, well, I guess it's all predetermined."… and there are some religious inputs into this.

Hilbert was very much… Hilbert was trained as a Calvinist. That is the Calvinist view, and you can see it reflected in the mathematics. We can't get away from our upbringing sometimes. It influences what we think is obvious and what isn't. So, bottom line, all these symmetries, all symmetries in physics… Well, now, be careful with that… *Many* of the symmetries in physics are constructive. They require that you *create* the environment in which it applies. Other ones are interpretive symmetries. They just tell you *how* to interpret that. So the relativistic Doppler equations… Those are interpretive symmetries. They tell you how to interpret the world. But you need to pay attention to the *scope*. Now, the interesting thing is this also applies to the Standard Model all the way down to those individual particles.

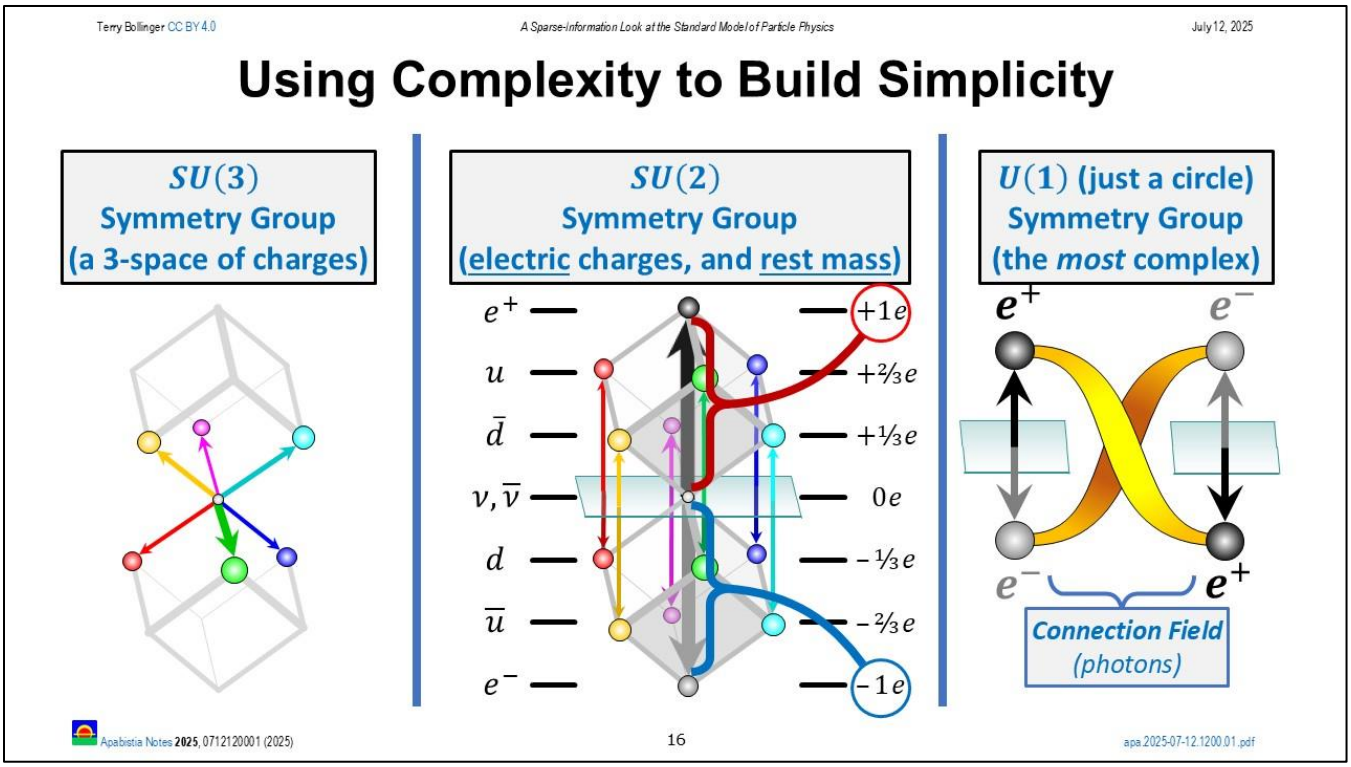


[53:32] What this winds up doing in terms of things like condensed matter particles… Where do they come from?… This is a slide I've used before, but I just like the message in this. There is an underlying connection on many of these issues. This, in particular, was one when I was dealing with centrifugal force. Angular momentum. Angular momentum goes all the way back to some deep origin of the universe, in which we all share the same definition of what is a move… what is rotating and what is not rotating. And to this day we all share that. But our definition is isolated. We don't have instantaneous interactions from distant parts of the universe. The galaxies don't tell me that I'm rotating. But the distant galaxies did have a relationship that is stored all the way down into the individual atoms of my body that says "This is not rotating, and this is rotating."…

So the term I use for this is compact shared universe. This is different from a Big Bang type. Big Bang just says "Boom! Everything, you know, explodes. Blah blah blah!"… This is more subtle. This is saying that there's a point of sharing in the past where all these things have a common definition, and we never lost that. But we did get separated in this vacuum of space. So now we're an isolated unit of that. This, again, goes all the way down to the particle level, because particles also spin. That's actually a very explicit example. If this applies, what is spin and what is not spin is defined at the macroscopic level by this dissection process. It also applies to particles. They somehow know what that original compact shared universe, that original image (if you want to use the mirror analogy), what that looked like.



[55:14] What are the mirrors of reality? Now, here's where I really start getting into the Standard Model, and I'm already late on time. So a good part of this (probably when I get to the part where I've given a specific elaboration), I'm just going to go through that very quickly. So here are the main particle groups, and [what] the main message I want to get over is. They're called U(1), which I already talked about. It's just a circle. You can talk about complex numbers. You can talk about all sorts of things, but it really is just a number. It's a number with one axis. It's things flipping upside down [along (?)] one dimension. Then you have SU(2). It's also two-dimensional. Now, there's a lot more to it because you've got complex numbers. They add the number of total effective dimensions. But it's still just talking about basically through two orthogonal axes… SU(3)?: three orthogonal axes.



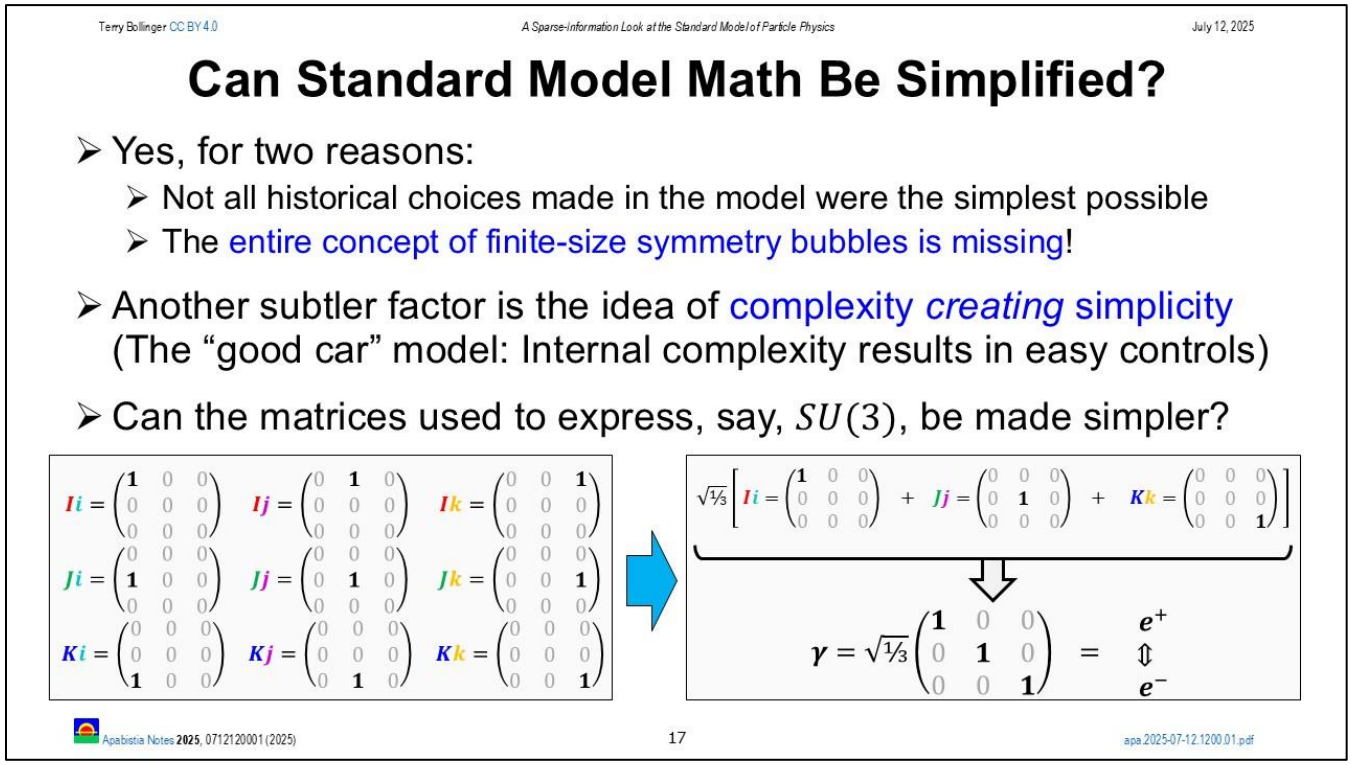
[56:05] So, and in a quick nutshell, the SU(3)… One way to understand it… This is the simplest way I can think of to understand what goes on with this SU(3) symmetry, and this is a simpler representation that you usually see, is you have three orthogonal axes. In other words, it's a 3-space. It's a 3-dimensional space, not some exotic space. It's not the same as our 3-dimensional space, but it is a 3-dimensional space, and it's a space of charges. So if you want to think of it as sequence. That's the first level… Remember, I said, these mirrors kind of stack up on each other. So you have a first set of mirrors, and you have a second set of mirrors on those mirrors, and you build up. So this is the first and really the most remarkable innovation of the universe is this idea of orthogonality.

Three orthogonal charges… They don't quite get along with each other. They're all different. They're different axes. Each one is, you know, if you go this way you're not going that way, just like 3-dimensional space. But again, this is a charge space. Now, the next step is where you get this, this symmetry group of electric charges. They talk about transformations… the gate transformations of a semigroup. They usually don't mention in terms of charge, and I'm intentionally invoking electrical charge.

For instance, the symmetry they talk about is this… originally it was started as… somebody knows that neutrons and protons were very, very similar and someone said "Well, maybe they're just a rotation of each other."… And then you have this elaborate discussion about how… "Well, yes, but it creates a field. If you do that…"… the discussions kind of miss over the point is that you're just adding charge. You know, that the real difference, the dimension that you're adding is charge, going up or down one Newton charge. And suddenly you get this relationship between a whole bunch of nodes of these two cubes.

If you look at those nodes that I'm showing there, those are the particles of the Standard Model. And right in the middle (kind of simplifying it) are the electron and the positron. Now you take that symmetry, move it over to the next one to the right. and then you get this this different effect. You want to… See how complex it's gotten. You started there, fairly simple, got complex, and then on the right hand side, the U(1), you suddenly get simple again. It just turns into a coil. It just turns into a spring. You say "Oh, a photon is just a spring-like connection between these two definitions of charge: up and down."…

And this is one of the tricks of how the Standard Model (I would suggest) accomplish what it does. These aren't just isolated symmetries. And, by the way, I don't even know if this is highly non-standard or standard. Might be standard in some paper. But what I would suggest to you is that the building of the mirrors is important, and sometimes the construction winds up in simplicity. So if you *start* with the electrons and *start* with the charge, you're missing the boat. You want to go back to the *messier* parts and say, well what's going on with those messier parts which leads to this kind of simplicity and this kind of connection.



[59:23] Now, the part I'm not going to go over is an actual example of how this kind of thinking can wind up collapsing complicated sets of mathematical formulas, matrices into simpler sets, using an ijk notation, which is from a mathematical concept called quaternions. Think of them as a three-dimensional generalization of complex numbers. And, if you do nothing more than go back to this figure, and look at those three charges, those three charge dimensions, and how they add, you wind up with a much simpler version of how these matrices work out, and that's what these matrices on the right are doing. They're saying that charge, electrical charge, and color charge… even though the color charges are only seen inside of protons, they're actually very closely related, because we only see them in nature in combination. You never, ever see a color charge without an electric charge. They are always combined. They form a vector. This previous cube here?… That's those vectors. Those are the Glashow vectors.

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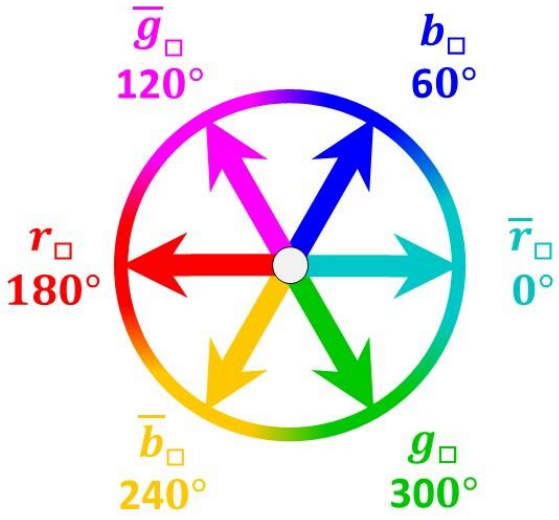
$SU(3)$ Has Six Units of (Pro-Anti) "Color" Charge



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[1:00:29] Now, that winds up… Here's what you do in Standard Model. Again, I'm not going to go through it. The Standard Model uses a flat definition of these colors. That's the the ones without the electrical charge.

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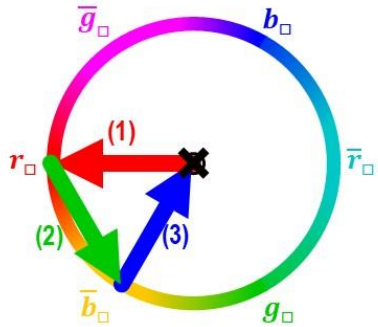
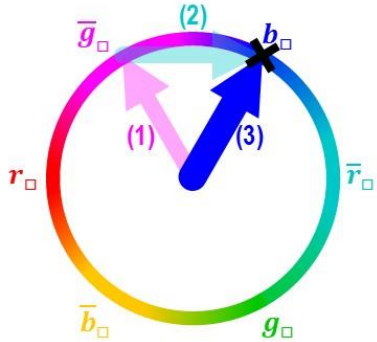
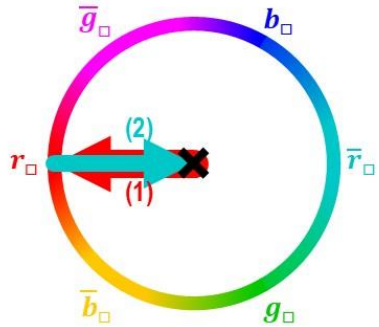
Color Addition in Strong Force Particles

$r_{\square} + g_{\square} + b_{\square} = \emptyset$	$\overline{r}_{\square} + \overline{g}_{\square} = b_{\square}$	$r_{\square} + \overline{r}_{\square} = \emptyset$
E.g., proton p, neutron n	E.g., blue up quark u_b	E.g., pions π^0, π^+, π^-
		
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[1:00:42] You combine them in different ways.

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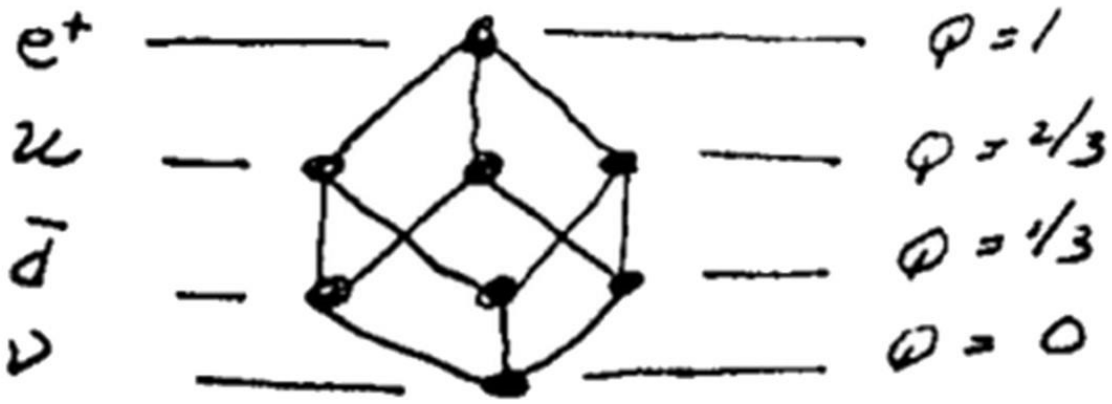
The Glashow Fermion Cube



S. L. Glashow, "The Future of Elementary Particle Physics [HUTP-79/A059]," *Harvard University Preprints*, Jul. 1979. Available: https://inspirehep.net/literature/144466. Page 29, Section III, *Let the Desert Bloom!* S. L. Glashow's original hand drawing.

[1:00:44] Glashow, who created the Standard Model, was the first to notice that there's cubes. There's this cube construction,
where you have the colors elevated from each other by the electrical charge, and I don't know if it's actually Glashow. I think it was one of his coworkers who probably came up with this because he mentioned it, but he certainly didn't get into in detail. But that's the same cube that I just showed.

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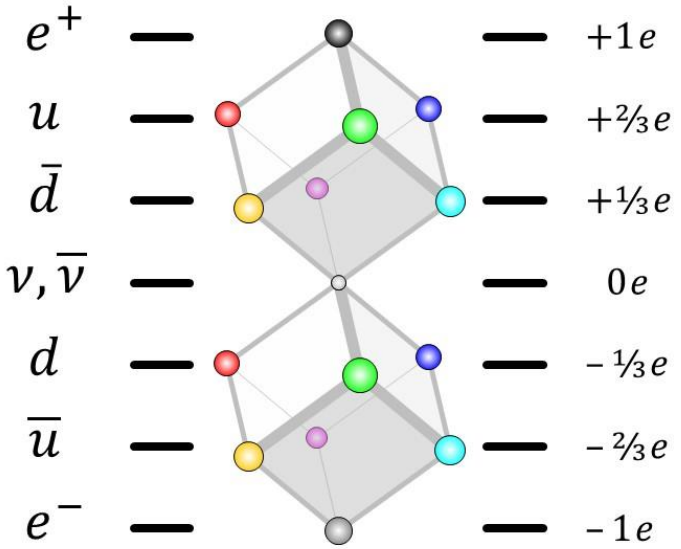
Adding the Second Glashow Cube



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[1:01:02] And in fact, there are two of them, and those are the two I showed you earlier.
Those are the two that pop out of the Standard Model. If you go through the different symmetries and try to construct and say, "Well, what's the simplest way I can construct some of these symmetries?"…

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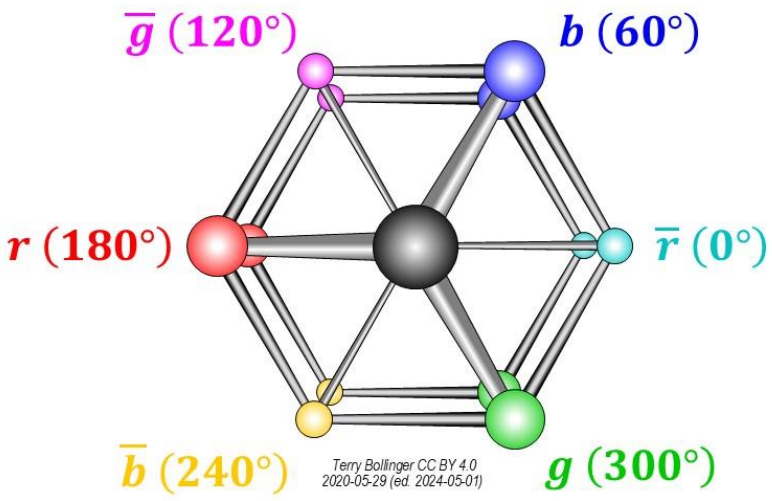
Top-Down View of Glashow Cube Colors



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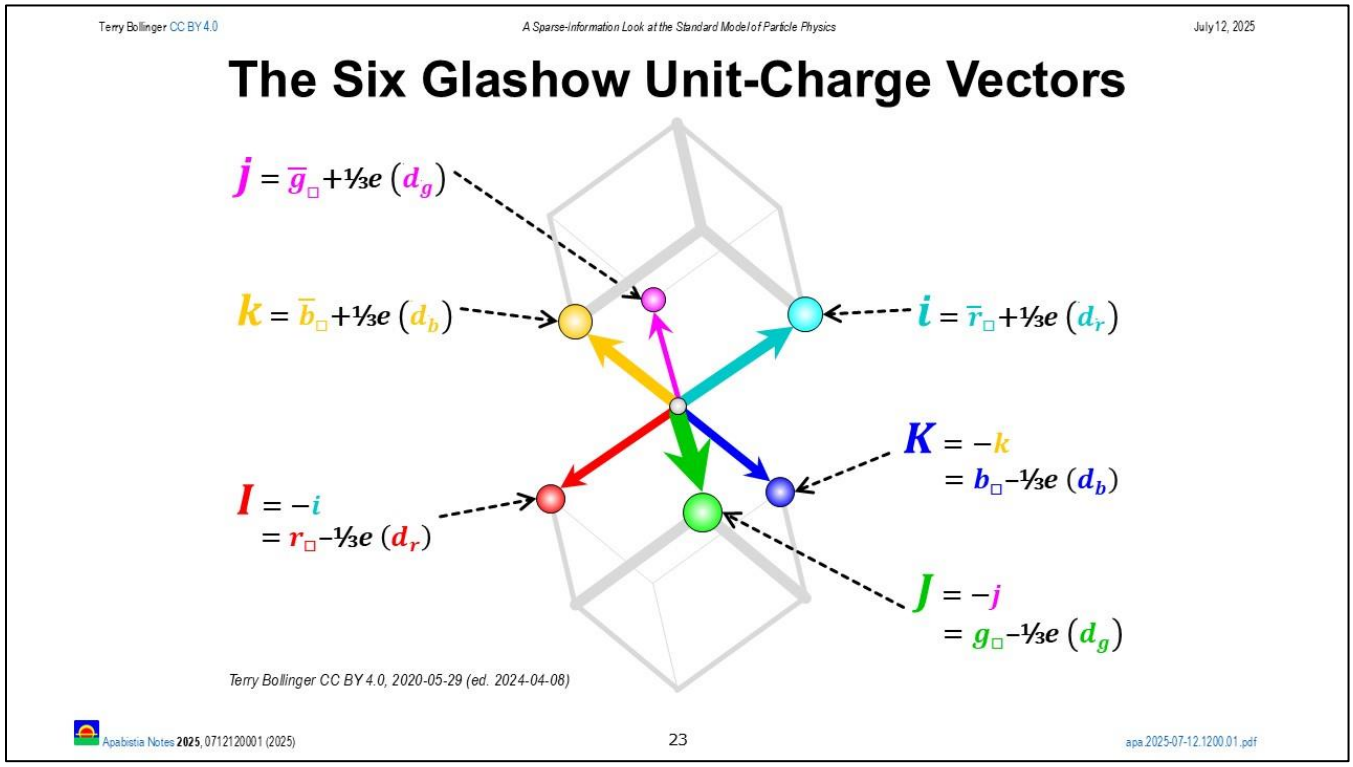
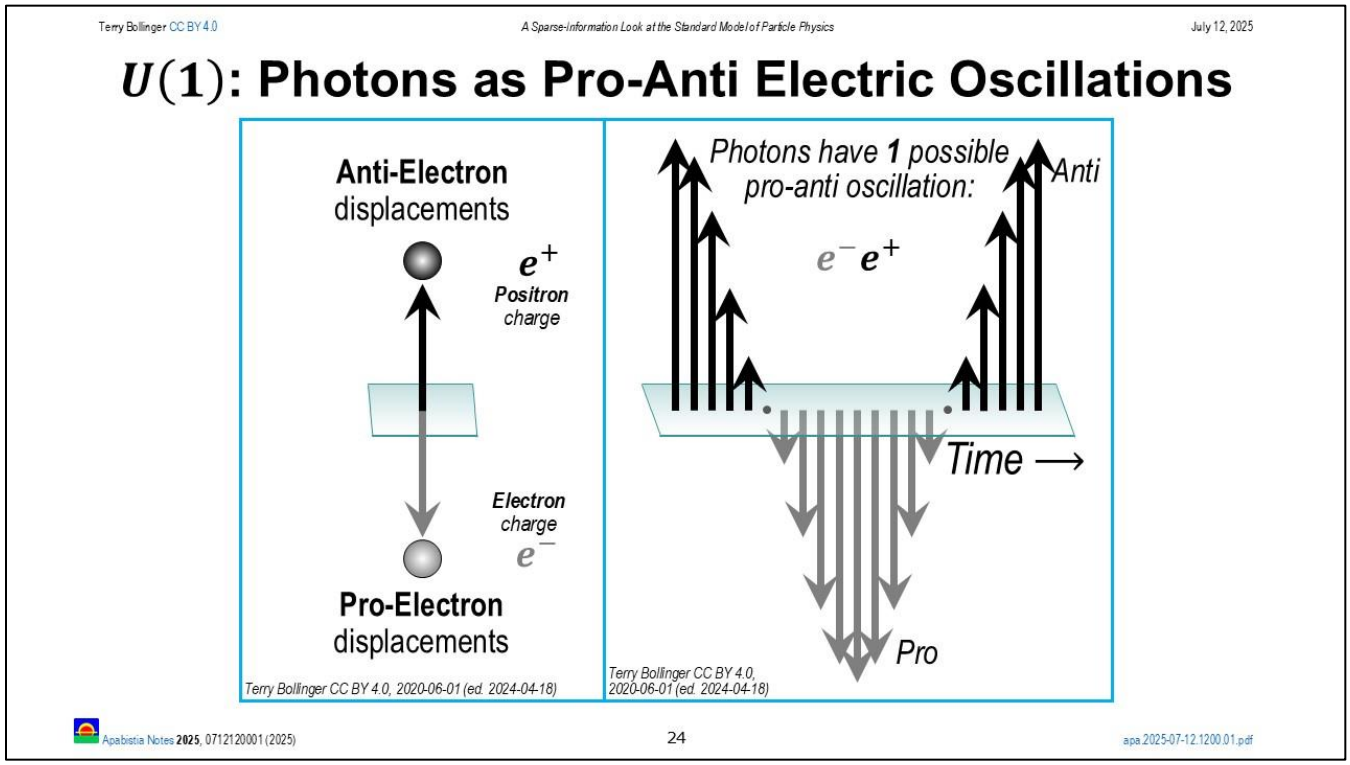
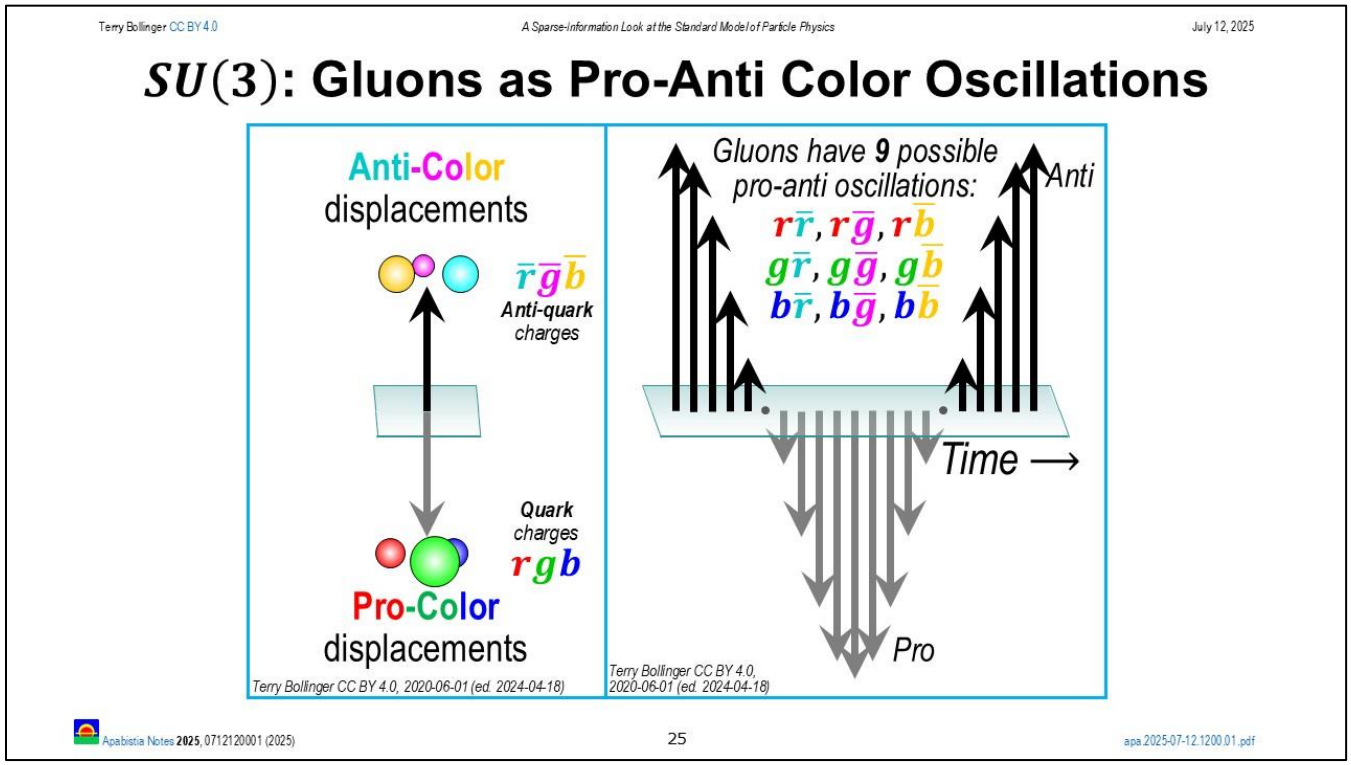
[1:01:16] Here's what it looks like from the top down.



[1:01:18] There are those charge numbers again, just defined with the… using the quaternion notation.



[1:01:26] This is a point where I'm trying to simplify some of the ideas of the same thing I put as a coil before… Here I'm describing [it] as a vibration.
So you have a proton. You have a electron. You have the charges. Then you have… The photon is the oscillation between those two charges.



[1:01:44] Then you have *this one*, where you have the quark colors.
And guess what? You can define different combinations there, but you get a lot more of them. You get *nine* of them, because you have the pro and you have the anti colors here, and they combine in a similar fashion. So you get a lot more vibrations. These are the gluons. So we had the photon here… was the electron-positron vibration and the gluons are really just the vibrations between the different polarities of positive and negative color charge.

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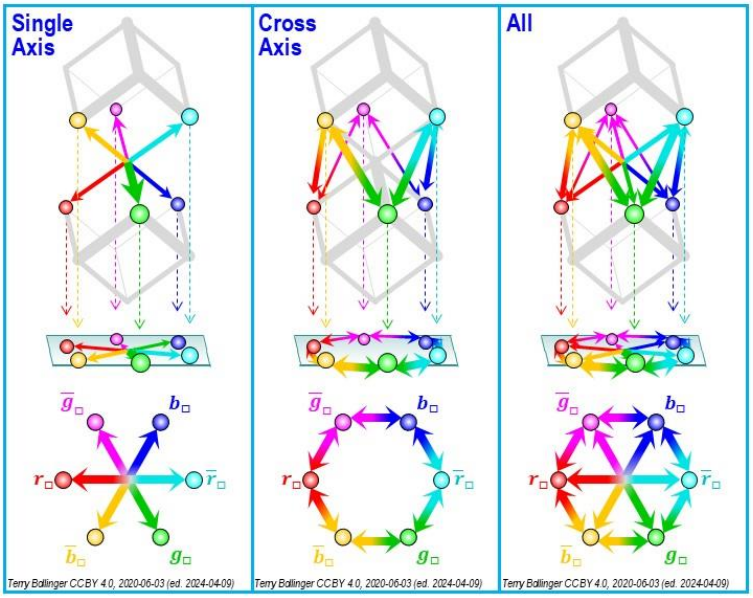
Color Oscillations in Glashow and Flat Coordinates



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[1:02:14] Except there are only eight gluons. Why are there eight gluons?

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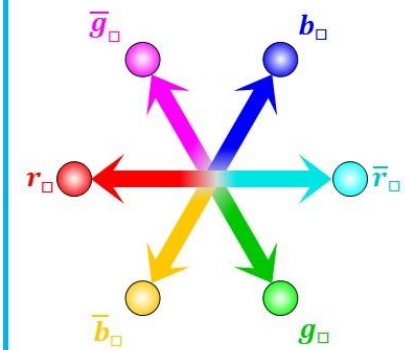
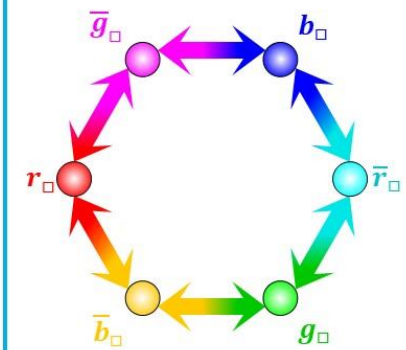
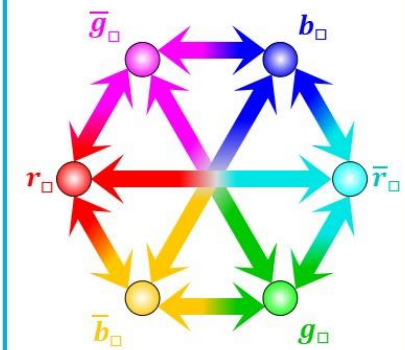
Mystery of the Missing Gluon

Same-axis charge point pairs result in **3 single-axis** gluon oscillations that, like photons, carry only energy & momentum.	Perimeter edge charge pairs result in **6 cross-axis** oscillations that carry color in addition to energy & momentum.	**3 energy-momentum** oscillations plus **6 color-carrying** oscillations gives **nine**. So why are there only **eight** gluons??
		
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[1:02:19] That's what the rest of this is about. And again, we're at the end of the time, so I'm not about to go through that full set, but there's a fascinating set of how these things relate and how we got into this situation.

Standard Model Color Oscillation Space as a Donut

One combination of flat colors places "pro" and "anti" at the same location

$$\bar{r}_{\square} + \bar{g}_{\square} + \bar{b}_{\square} = \emptyset$$

$$r_{\square} + g_{\square} + b_{\square} = \emptyset$$

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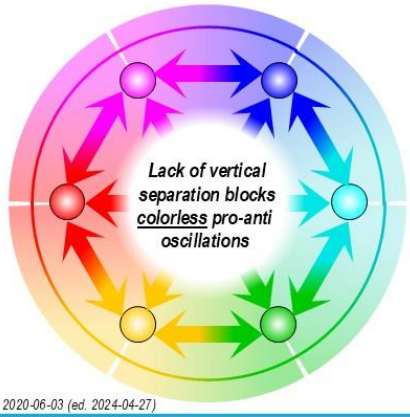
The Forbidden Oscillation: *With flat color there is a zero-amplitude "hole" in the vertical oscillation space — and thus, a missing gluon*



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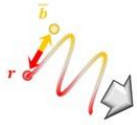
[1:02:34] You wind up with this problem when you use flat colors: When you use the definition where you completely isolate color from electric charge, you wind up with a hole.And that's why you have to reduce the number of dimensions. You got a hole in the middle of your construct, because these two combinations, the one on the top and the left and the one on the bottom and the left, give you the exact same amplitude, so you can't create a vibration there.

Standard $SU(3)$ Matrices Add More Dimensions to "Dodge" the Donut Hole

Matrices concisely define pro-anti oscillations:

$$r\bar{b} = \begin{array}{c|ccc} & \bar{r} & \bar{g} & \bar{b} \\ r & & & 1 \\ g & & & \\ b & & & \end{array} =$$



The 9 expressible oscillations looks like this:

$$r\bar{r} = \begin{pmatrix} 1&0&0\\0&0&0\\0&0&0 \end{pmatrix} \quad r\bar{g} = \begin{pmatrix} 0&1&0\\0&0&0\\0&0&0 \end{pmatrix} \quad r\bar{b} = \begin{pmatrix} 0&0&1\\0&0&0\\0&0&0 \end{pmatrix}$$

$$g\bar{r} = \begin{pmatrix} 0&0&0\\1&0&0\\0&0&0 \end{pmatrix} \quad g\bar{g} = \begin{pmatrix} 0&0&0\\0&1&0\\0&0&0 \end{pmatrix} \quad g\bar{b} = \begin{pmatrix} 0&0&0\\0&0&1\\0&0&0 \end{pmatrix}$$

$$b\bar{r} = \begin{pmatrix} 0&0&0\\0&0&0\\1&0&0 \end{pmatrix} \quad b\bar{g} = \begin{pmatrix} 0&0&0\\0&0&0\\0&1&0 \end{pmatrix} \quad b\bar{b} = \begin{pmatrix} 0&0&0\\0&0&0\\0&0&1 \end{pmatrix}$$

Mixing the expressible oscillations and adding imaginary factors creates a new set of 8 finite-amplitude gluons that still result in real-quark charges of $r, \bar{r}, g, \bar{g}, b, \bar{b}$, but use higher dimensional topologies to navigate around the zero-amplitude donut hole in flat oscillation space

$$\lambda_1 = \begin{pmatrix} 0&1&0\\1&0&0\\0&0&0 \end{pmatrix} \quad \lambda_2 = \begin{pmatrix} 0&-i&0\\i&0&0\\0&0&0 \end{pmatrix} \quad \lambda_3 = \begin{pmatrix} 1&0&0\\0&-1&0\\0&0&0 \end{pmatrix}$$

$$\lambda_4 = \begin{pmatrix} 0&0&1\\0&0&0\\1&0&0 \end{pmatrix} \quad \lambda_5 = \begin{pmatrix} 0&0&-i\\0&0&0\\i&0&0 \end{pmatrix}$$

$$\lambda_6 = \begin{pmatrix} 0&0&0\\0&0&1\\0&1&0 \end{pmatrix} \quad \lambda_7 = \begin{pmatrix} 0&0&0\\0&0&-i\\0&i&0 \end{pmatrix} \quad \lambda_8 = \sqrt{1/3}\begin{pmatrix} 1&0&0\\0&1&0\\0&0&-2 \end{pmatrix}$$

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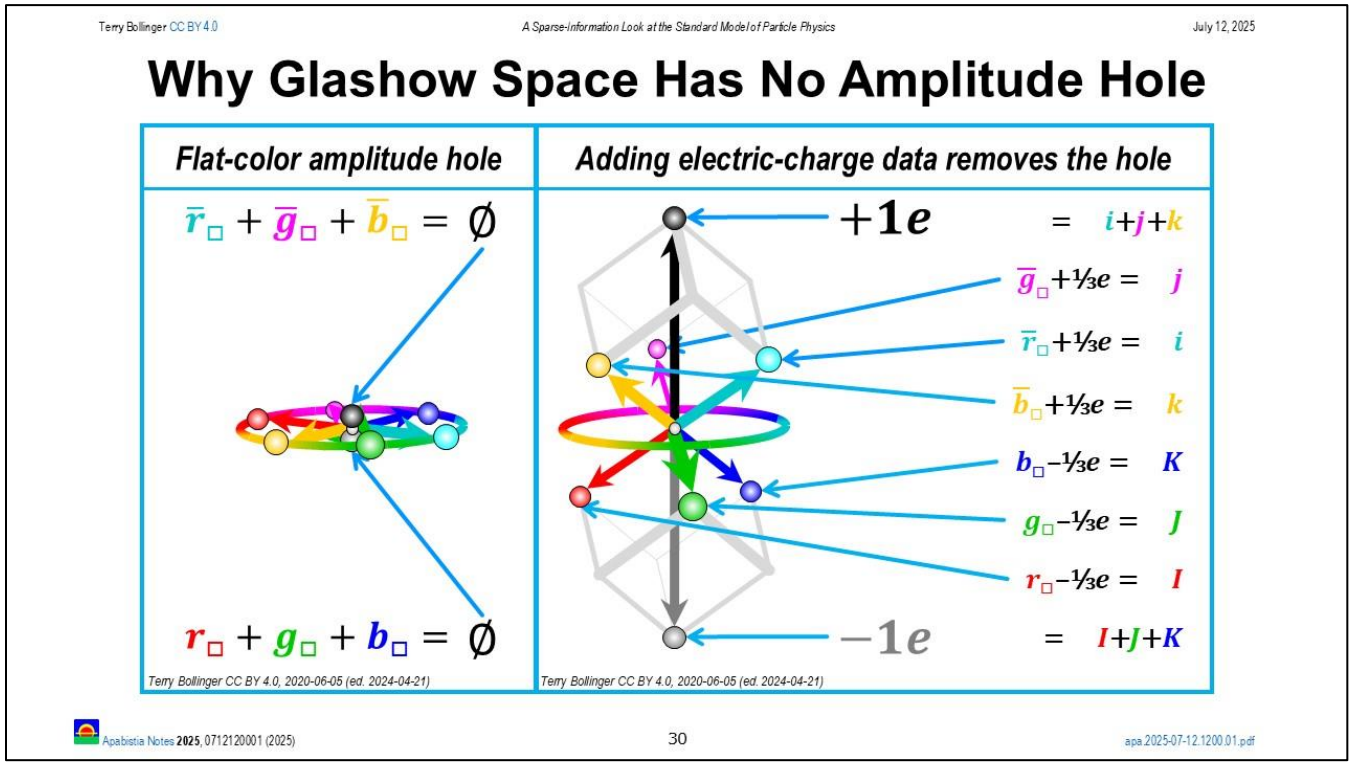
[1:02:56] This made a *mess* out of everything! It got really complicated… Matrices… The result… You see this one on the right and get this… And this is just one of many, because once you once you create that hole, it just messes up the simplicity. So you've got the basic nine definition vibrations on the left. Then you've got this horrendous mess on the right, that's trying to navigate around the donut hole. You're trying to get away from that donut hole.



[1:03:22] But the Glashow space I mentioned earlier doesn't have that problem, *because* observing and sticking rigidly to what we actually see, you only see color in combination with electric. So I say, well, wait a minute. Maybe there's a relationship. There is! It's a very simple relationship. Those charges, which are actually the charges of anti-down quark, are the actual axes of this space, and this space in turn turns out to be the same as Maxwell's electric displacement space, just with more dimensions, and his vector is the one right in the middle: electron-proton.

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Chromoelectric (CE) Matrices Make Maxwell's Displacement into a 3-Space

All 9 pro-anti oscillations are force particles:

$$Ij = \begin{array}{c} \begin{matrix} i & j & k \end{matrix} \\ \begin{matrix} I \\ J \\ K \end{matrix} \begin{pmatrix} & & 1 \\ & & \\ & & \end{pmatrix} \end{array} = {}_{I}\!\sim\!\!\!\sim_{k}$$

The 9 expressible oscillations are the particles:

$$Ii = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad Ij = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad Ik = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$
$$Ji = \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad Jj = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad Jk = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}$$
$$Ki = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \quad Kj = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix} \quad Kk = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

An equal mix of the three momentum-and-energy-only chromoelectric diagonal particles gives rise to a particle not possible with flat color. This force particle has no net color when oscillating, but instead oscillates on Maxwell's vertical (electric) axis. It is better known as the ***photon****.*

$$\sqrt{1/3}\left[Ii = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} + Jj = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix} + Kk = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} \right]$$

$$\gamma = \sqrt{1/3}\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{matrix} e^+ \\ \Updownarrow \\ e^- \end{matrix}$$

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[1:03:57] So you see how it builds up? You start with these things that are *not* stable, that are *only* occurring inside of protons, and they have some other way of combining within another space in the CSU, and then it gives you the electron. But it's still just a constructive process. So you start with messier things, and wind up with *click!*… You get this nice little electron-positron polarization.

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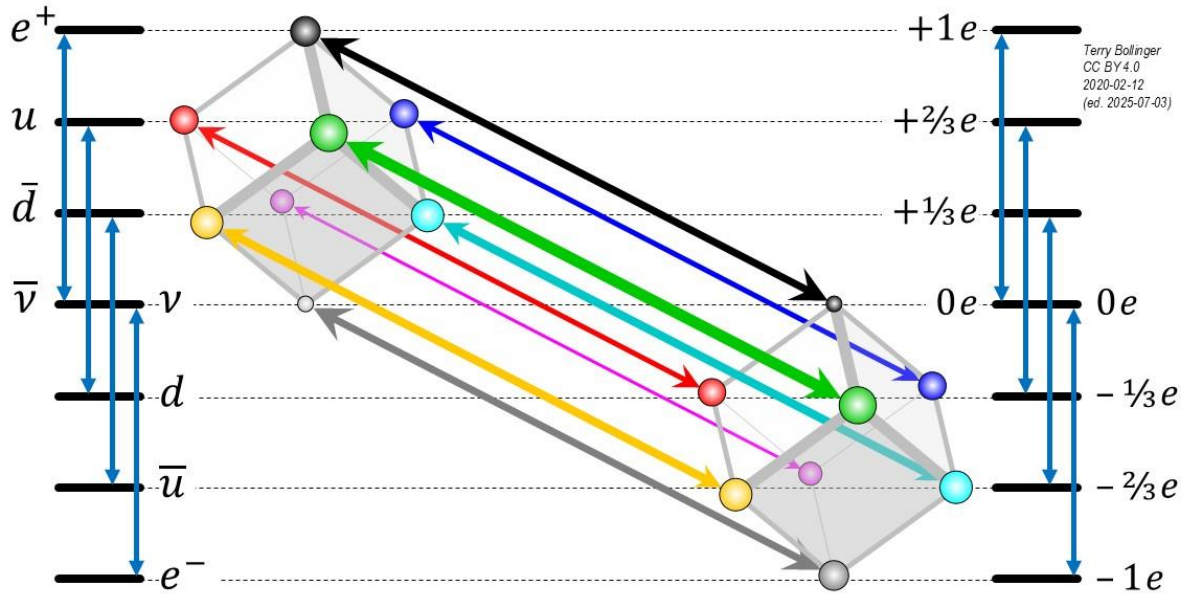
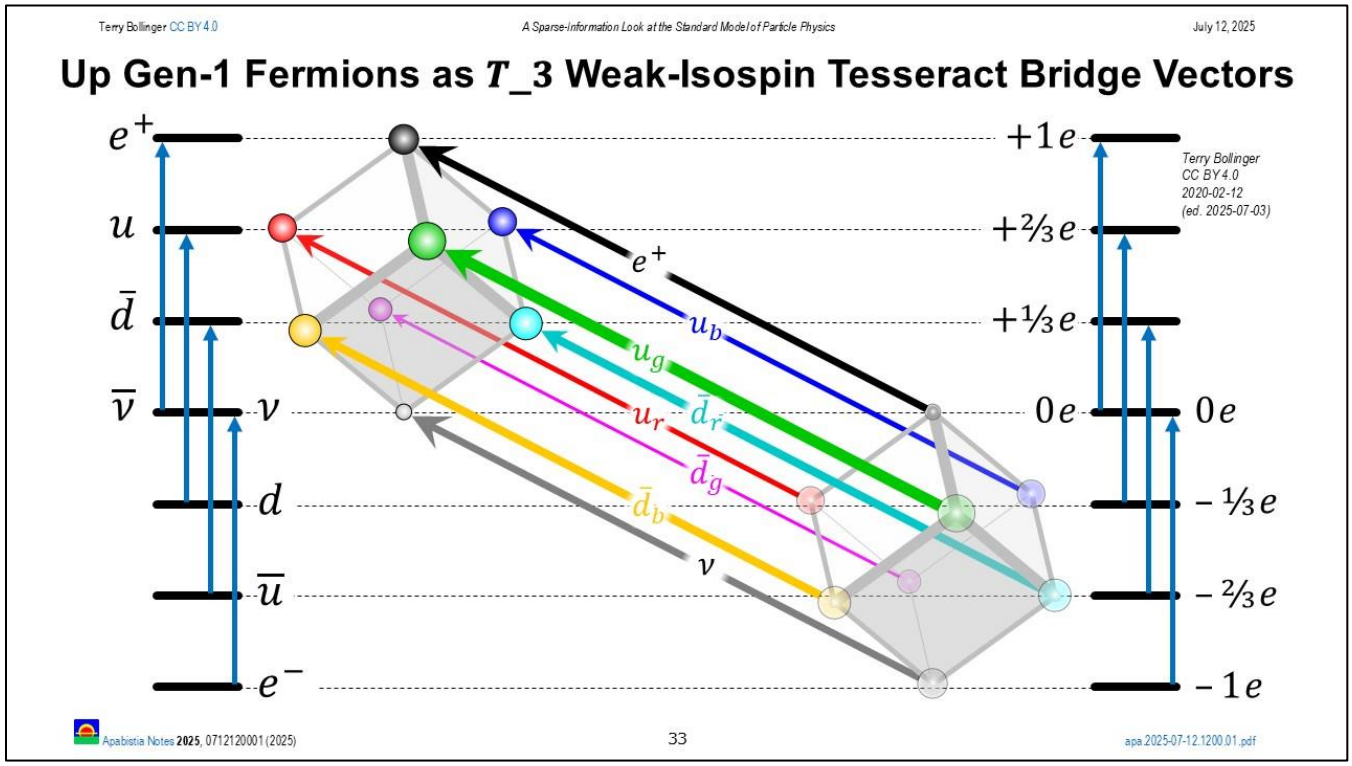
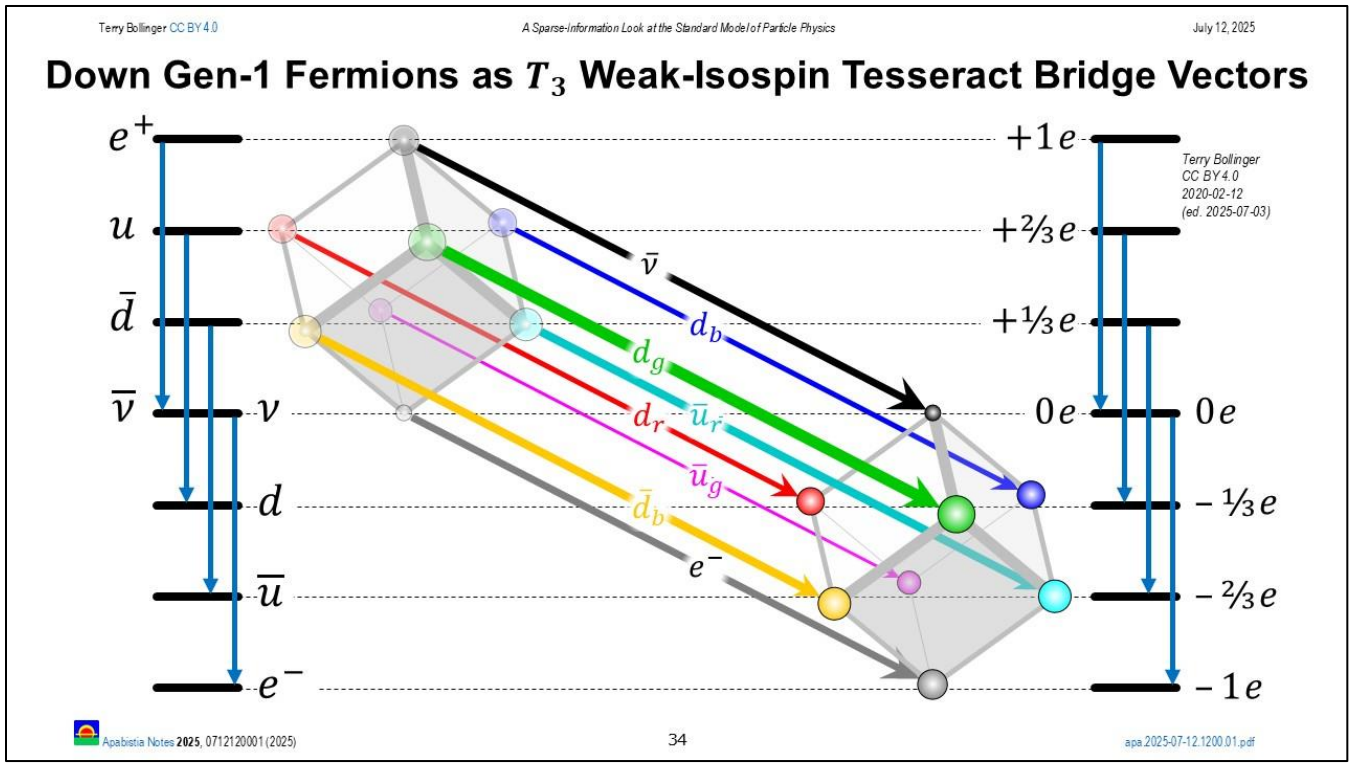
$SU(2)$: Gen-1 Fermions as T_3 Weak-Isospin Tesseract Bridge Vectors



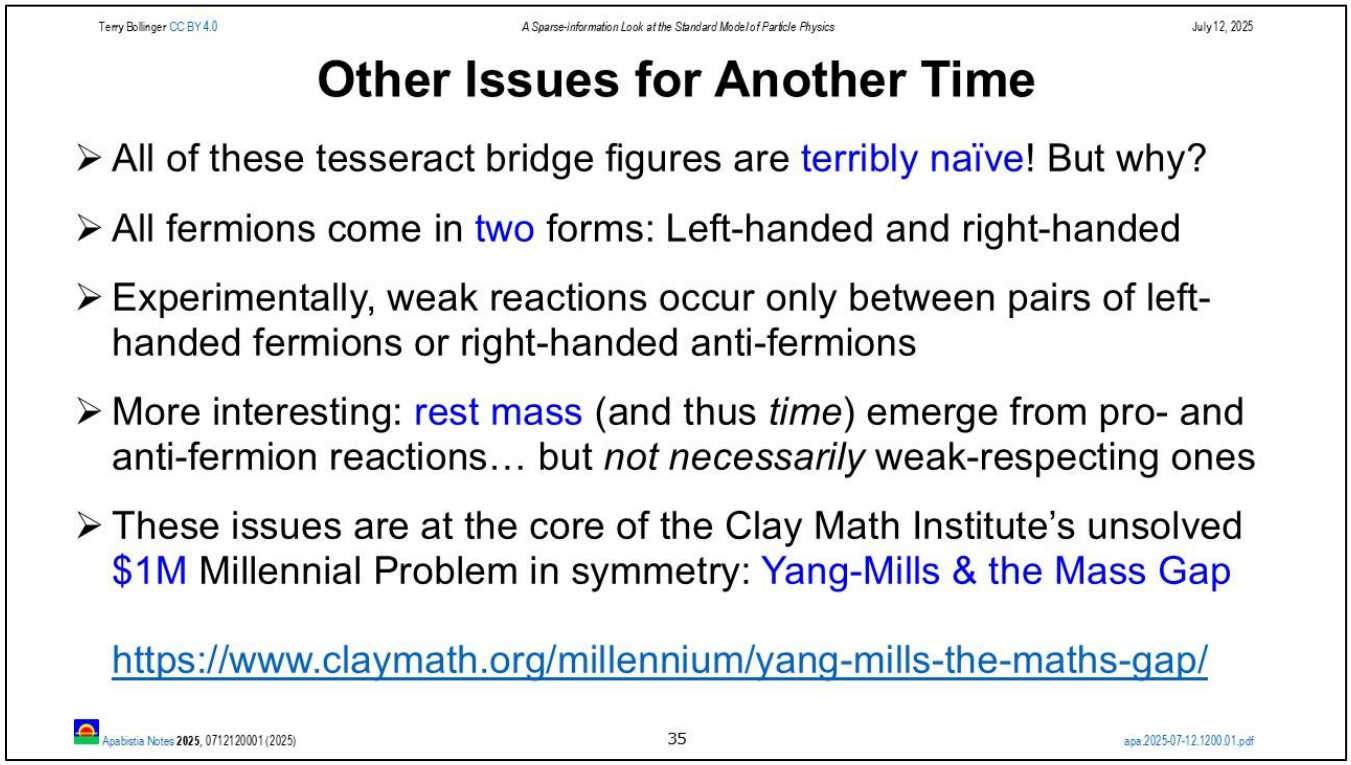
[1:04:22] Here's another way of representing it: If you really want to get into the terminology… Oh, you take those same cubes, and you can think of them as 4-dimensional and you can think of them as having bridges. The charges are now bridges and the bridges are called weak transitions. There's a name for this. The T_3 weak isospin tesseract bridge vectors. So, the bridge vectors part is my idea. The T_3 weak isospin is the name that comes from the literature, and it's amazing sometimes how complicated naming simple ideas can get. It's really just the electric charge transition between two types of particles. What types of particles? Electrons go to neutrons. Anti-neutrinos go to positrons in the bottom. Up quarks go to down quarks. All these things just pair off in a very natural, very easy fashion. And what's remarkable is a simple figure like this captures a huge chunk of the Standard Model in terms of those relationships. You have the weak force going on here, with those bridge vectors. You have the electric charges, the color charges. You're showing the different transitions. You can derive from this the vibrations, like I did earlier. So a surprising amount of the Standard Model can be simplified to a fairly simple diagram of this type.



[1:05:44] There's your up quarks. Got it… So yeah, up and down turns out to be important. So you have the up ones, where they have this spin up different. They go in a positive charge direction.



[1:05:52] Then you have your down ones. They go in the other direction. They have a certain relationship, a certain symmetry, a certain mirror relationship again. So it's just a fascinating ability to take some of this complexity, and all those different individual symmetries, and wind up with that… Other issues for another time!

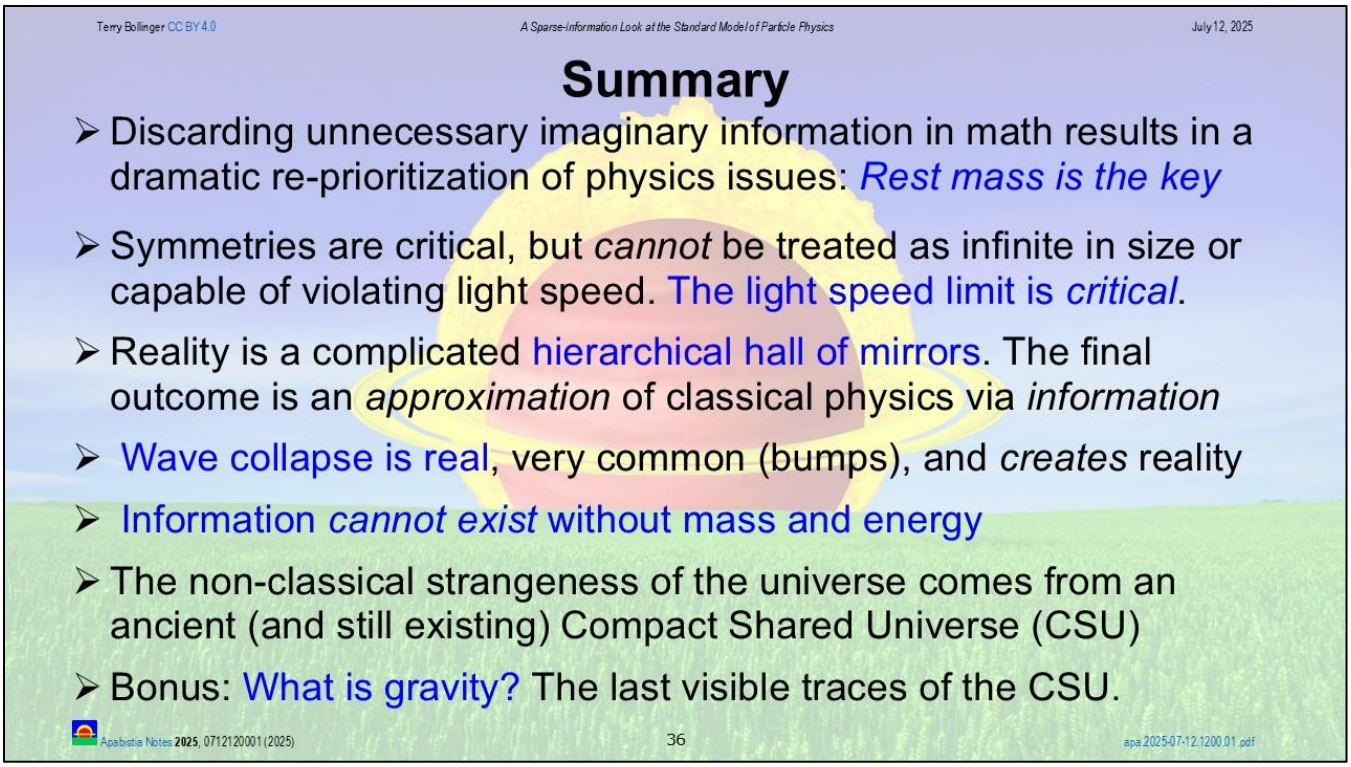


[1:06:15] The bridge vectors I just showed you are terribly naive. So why did I show you? Because I'm not going to get into left hand and right hand. But if you want to get into the *really* interesting issues (of where does mass come from, why are photons massless, why do neutrinos seem to be almost massless, although there's still some uncertainty about that) you have to get into a deeper breakdown, in which it turns out that everything I showed in the previous diagram was left-handed. It was a matter particle and right-handed it was an antimatter particle, and there's a whole set of other ones that don't go through the weaker interaction. They're immune to it. They have no effect on it. And interactions between these are where you start getting this idea of mass.

Now, why would that be important? Well, if you want to win a million dollars, you might want to look at that, because the rest mass is actually the meaning of the Yang-Mills and Mass Gap problem. Now they don't phrase it that way. They phrase it in a rather complicated thing, invoking a bunch of things, which are important to it, and actually important to get to the symmetries. But nonetheless, the real kernel of the problem is saying, how do symmetry groups manage to do this sort of stuff? And one of the ideas that I would contribute if somebody seriously wants to go after this… I have no interest in this problem myself. But I love the idea… I have no interest in what's going problem, but I would love to give some ideas that could help somebody win the problem. I think it would just be delightful or something to help.

One of the ideas I say that you absolutely have to bring into it to solve the Clay Math Institute's unsolved Yang-Mills Mass. Gap problem is the idea of locality symmetries. Because if you don't understand that symmetries themselves are local, then the whole idea of local symmetries and global symmetries in the Standard Model is going to get messed up in places. Not necessarily all. In fact, the very term local and global symmetries is almost unconsciously reflecting the fact that symmetries have scope. They have size. They have limits. But not in a clear way… It's not straightforward to do this… To win this prize you would have to bang hard on some mathematical foundations and say "Can we do symmetry groups that are only bubbles? Can we break them into pieces? Can we show ways that they're connected that only show up if you realize the local locality of them?"… And again, I would say that the Standard Model is kind of doing that where they have the electron and it showed the two things where they're showing how they're different. That is addressing that issue. You're saying that "Oh, I've got, you know, different symmetries over here, different spins. And they all share this global definition of what that spin is."…

So it's there, but I think it'd be stated more clearly, and you also need to fix things like disrespecting the relationship of color and electric charge, because until you do that, you just get a massive, noisy math. You're not really tracking the simple cubic complexity that's going on underneath that. So there's the place you're going to go read up in Yang-Mills math problem. The actual phrasing of that is all about that proton-neutron symmetry call. That's a very old symmetry. And again, the paper, the abstract amuses me a little bit, because they say "Well, if we flip these things around, there are field implications."… Well, of course there are! You added electrical charge to the particle, so how could there *not* be field implications? But it's doing it in a much more precise language, and that allows you to make predictions that you can't make with just that offhand comment.



[1:09:57] And with that, summary: Discard imaginary information. It just messes things up. Rest mass is key. If you can't reflect your complexity of your math back to actual mass and energy, you're probably off in some mathematical abstraction that is based on 1700s assumptions that [the] classical universe is infinite. Symmetries are critical. Oh, the other thing I mentioned about symmetries: They are finite. Some of them are interpretive. Some of the other ones are finite. Critical light speed is light speed that impacts symmetries. The reason why the Poincaré symmetries are finite and bubble is because they're not infinite speed. You can't just throw them out there, and everything just suddenly works. You can do that with interpretive symmetries like the relativistic Doppler, but you can't do that with ones that require changes, for the same reason we always know: the speed of light. So you got to respect the speed of light *in your math*. If you don't, you wind up with things that don't matter.

The idea of viewing all of these as halls and mirrors… You can get into all the complex mathematics and a lot of terminology, but I think that's the key concept to keep in mind: This is a hierarchic hall of mirrors. The other thing I mentioned (again, to emphasize): wave collapse is real. If you don't get the idea that wave collapse is an incredibly common phenomenon you can't get deeper into these issues. Yeah, because that's really where some of the interesting stuff starts popping out is saying "Well, what do I do that does not collapse the waves? What is the deeper nature of the uncollapsed part of reality?"… This CSU… this Compact Shared Universe. Information has to have mass and energy. You can't just arbitrarily say that a black hole is full of information.

Come on! You have to have machinery to make bits. You can have more informal forms of information, but it doesn't work that way. There's a lot of work you have to do with that. So this idea of a compact shared universe is is where you get this weird strangeness that should come from the quantum side: these entanglements. And, final thought, bonus idea, what is gravity? Well, if space and time are created by matter, they have finite limits. When you start bumping into those limits, reality starts reasserting itself that the underlying reality says "You know, you need to come back here..." and working that out as an actual formula that could be very interesting, but that is the the basis of saying "Where's this gravity coming from?"… It's the lack of acceleration, which is the equivalence principle. Gravity is the lack of acceleration and that's telling us something important about where it comes from. And with that I am done. So, open to questions if you dare!

Questions and Answers from after the presentation:

TX = Team OrionX (Helen Ma)
TB = Terry Bollinger
GZ = George Zipperlen
DF = David Fenner
CP = Caetano Peng
BB = Barry Burd
LB = Lynn Beran

[1:13:10] TX: Oh, I noticed there's a question from Marco. What about the de Broglie wavelength instead of quantization of linear momentum.

[1:13:26] TB: Yes. Oh! What was the question again?

[1:13:28] TX: What about the de Broglie wavelength… Isn't that a quantization of linear momentum.

[1:13:39] TB: The de Broglie wavelength is… it's… When you say, quantized in a sense of angular momentum, angular momentum occurs only in discrete units. So, an atom for an atom or electron can only have one state of angular momentum. That's where the difference is. They're all wavelength phenomenon, but linear momentum de Broglie wavelength… If you have a particle that's not moving at all its de Broglie wavelength becomes infinite. If you have a particle that's moving very fast relative to the observing frame, it becomes extremely high. So it's a continuum. There's no point at which you cannot have a wavelength. You can have any momentum that you choose.

So that's what I mean when it's not quantized. So photons behave that way. You don't have discrete *energy levels* of photons. You only have discrete *reception* of the photon. That is, the energy… when you *grab* the energy, that's quantized. But if you treat the photon as a momentum effect (the wave effect) it's not quantized, and that can really throw you off in the calculations, but I mean, this is… I've seen people get themselves in the loops about how's the photon imparting momentum to that solar screen? This is a very well proven effect. And you can't handle it with QED. QED does not have the mechanisms there except you just abstract it as a potential, and then go from there. So, non-quantized simply means you have an infinite range of wavelengths all the way down to 0, and which is certainly true for linear momentum. And for photons, you can also do that. But the energy itself when it's absorbed is quantized. Other questions?

[1:15:30] TX: I noticed George Zeppelin has a question. I always wonder if the quantum field theory ground state was just 19th century answer with 20th century chrome planting… Yes, you're on mute.

[1:15:49] TB: George, did you want to ask?

[1:15:51] GZ: Oh, yes! Is?…. Can you hear me?

[1:15:53] TB: Yes.

[1:15:54] GZ: Wow! This is amazing. It worked first time. So first, thank you for a wonderful talk.

[1:16:04] TB: Thank you.

[1:16:05] GZ: Oh, yeah… It's maybe always one that is a bit wrong, ut after I started to learn about quantum and it it got further and further away from observation, as you said, with this vacuum being a seizing thing of objects popping in and out of existence and so forth… And I… It struck me as if that was just a weird way of resurrecting the 19th century idea of an *ether*, which is an invariant rest frame.

[1:16:46] TB: It absolutely is because the only way you can make that work (and this is a discussion I've had with some physicists years ago)… The only way you can actually make that work is if you create a different infinite vacuum for every single observer frame and there's no way you can make this work… the cutoffs, the Wilson cutoffs that they use. As soon as you do a cutoff, you've created a frame dependency! So yeah, you've got a cutoff for your frame, but how about somebody else moving at the speed of light? They're not going to see the same thing. You cannot take the… It's interesting, but the way you've stated it… In many ways we have abandoned special relativity and it's sad because it's a *good theory*, and it challenges our minds and says that something's *really strange* here, but we want to so much go back to that ether concept because it's so comforting and it's so much the way we think it is, and that's one of the reasons why I'm very unimpressed with the Planck foam idea.

Plank foam idea (again): it's a single inertial frame concept. You can't get around it. You have to put limits on it. As soon as you put limits on it you say it's going to look different from different viewpoints. The only way you can make a vacuum that is truly indifferent to all points is for it to be empty. You know… It's kind of… Somebody going surprise, surprise! That's what most people thought for most of I don't know how many millennia. So, returning to those concepts… But you see… and the problem is this: as soon as you say that, then you say, then how's the light getting from that distant galaxy to me? And, boy, does that throw you over into some other turf, because what it really is saying is there's a physics of direct interaction with constraints that we do not understand even partially.

Quantum theory is not sufficient. Quantum theory just says, waves are particles, waves and particles are both classical concepts. Those are interpretations of this, this underlying reality, the compact shared universe. But you see fragments of that. Everybody has a definition of what is not rotating. That is straight from this compact shared universe. It's say… It's broken up, it's dissected, it's broken across by space, but it's still there. We all know

individually… and that's the real solution to Mach's paradox (Mach's… paradigm? [principle?]), the idea that, you know, how do I know relative to the rest of the universe, that I'm not rotating?

Well, the answer is, you don't care about the rest of the universe. You have that knowledge inside of your own matter. It's built in. You've never lost it. And that immediately affects things like particle physics, the definition of spin, the definition of energy. All those things come from that. These are very non-classical concepts. And, we like going back to classical. It's a constant temptation, because our minds are wired that way. But I think it's just fascinating and I think some of the mathematical potential… You know… I bang hard on the math sometimes, but I think there's actually marvelous potential for maths that are a bit more complicated that are more respectful of these relationships and we'd like to see where some of that goes.

[1:20:02] GZ: Thank you. And if I could indulge my window of having the mic, I'd like to come to Hilbert's defense a little.

[1:20:13] TB: Okay.

[1:20:17] GZ: Hilbert, the logician, Foundationalist, and so forth, wrote the foundations of geometry, which is the most rigorous logical foundations of geometry to date, and his… One of his proposed Hilbert problems at the turn of the century was to extend that to *all* of physics. But Hilbert *also* wrote a beautiful book which isn't as well known that's called *Geometry and the Imagination* which is all about the sense of wonder, the visual internal intuitions that we have.

[1:21:08] TB: I absolutely am unfair to Hilbert. Hilbert was one of the most brilliant people of that time. The work he did was just incredible. And the reason I kind of pick on him [is] because he also was the one who solidified the idea of indifference to information content. And that for me is a bone of contention… To go like… Yeah, you bet… You know Riemann did also… So I…

[1:21:39] GZ: Yeah.

[1:21:40] TB: You have to be careful with these concepts, because we… To me the classical world is just the most amazing creation of physics. You know people talk about the classical world as being old… I think it's the other way around. I think the fact that we have a universe that shrinks the unit of persistence down to the size of an atom… that is so small that we *think* it's a point… It's just this incredible creation, because without that we would not have these definitions of space. We would not have these definitions of time. You can't have them unless you have something that approximates a point. Edward, bless his heart, was going down and elaborating that line about you know "What can you do with that?"… But again, my nitpick, is this… I always phrase it in terms of information which, of course, was not really a concept back then… Information—

[1:22:32] GZ: Yes.—

[1:22:34] TB: A block—

[1:22:34] GZ: It wasn't discovered or invented until Shannon, much later than Hilbert.

[1:22:40] TB: Yes. Well, Shannon and oh… I'm forgetting his name in Russian… The Russian mathematician… Does anybody know who that is? Thinking of… Oh shoot, I've lost it… There's a… I can't think of his name right now… [Minkowski?] He also has just marvelous work on information. I love his insights about what information is… And, I think one of the reasons why we keep slipping this idea that the universe might be a simulation is because information is what makes it tick. It's what makes it work and what makes reality real. But if, instead of thinking of an infinite number of of simulations, put it the other way around. It's a precious thing. It's a precious thing that our universe provides to us. It gives to us. It makes it persistent enough that

information has meaning, and without that we don't have life, we don't have existence, we don't have chemistry. So, it's a marvelous kind of concept, and Hilbert did a great job of exploring that so… good point!

[1:23:46] GZ: Yeah, thank you. And if I can indulge you and the audience further, you have a very interesting take on the relationship between mathematics and physics. And I put it in quotes, "reality", because that's a philosophical question… And I'd just like to throw two more quotes out there. One is from the statistician, George Box, and I might be misremembering, but it's something like "All models are bad. Some models are useful."…

[1:24:28] TB: That's a good… Who is that? Who said that?

[1:24:32] GZ: George Box. He's a statistician, mathematical statistician… And the other quote is from John von Neumann, one of the founders of formalized quantum mechanics, One of the people who saw that the Heisenberg Born-Dirac interpretation was mathematically *equivalent* to the Schrodinger interpretation, and Schrodinger had an interesting take on mathematical—

[1:25:13] TB: And Neumann did that?

[1:25:14] GZ: Yeah.

[1:25:15] TB: Because I know Schrodinger equivalenced his work to the matrix formulation.
But I may have—

[1:25:22] GZ: Yeah, I may be wrong on the details, but maybe credit von Neumann with the first textbook where it was all written down.

[1:25:34] TB: [indecipherable audio]… I just don't remember exactly what it was, but yeah.

[1:25:39] GZ: … And his quote, which goes back to the ancient Greeks and to the questions of infinity and imaginary numbers, and so forth, was that… again… I've probably got it wrong: "All mathema—"… Oh, something to the effect that all mathematical abstractions are *strange*, but we get used to some of them.

[1:26:12] TB: I can—

[1:26:15] GZ: And I… This strikes me as one of the slippery points that that one can get into, is that we are so used to the numbers 1, 2, 3, 4, 5, and so on… and we've gotten used to the number 0, which took *millennia* to realize was a number, let alone negative numbers and complex numbers and infinities. So I'd like to put out there that actually, these ordinary numbers that we're used to and think are real are just as abstract as imaginary numbers, infinities, and whatever else one can get stuck on. Anyway, thank you.

[1:27:04] TB: To follow up on that very point, if you look at the concept of counting, you have to have the idea that you have a set, that you have a number of items that are similar enough that they merit being included in the same set. The moment you say that you've invoked cognition. You've invoked systems of considerable complexity that are capable of making lists, making definitions of predicates to define what it is. It's the idea of simple integer numbers is far more complex than people give it credit for, *if* you embed it in the full set of circumstances in which it applies. Because you have to have a calendar. You have to have a definition. You have to have some idea of what it is you're counting. You have to have a number of principles in place, and this goes back to the idea that the greatest invention of the classical universe (of the underlying universe) is this classicality, this ability to create information, this ability to process it in time, that we can create spaces of separation.

All of those go back to that. And I would say that *none* of those are fundamental to whatever is deeper down, which I sometimes CSU, I've been calling it lately, the idea of Neerakar, the idea that some conserved quantity,

but it really is formless, and I'm borrowing from the Sanskrit term. It seems to be the most apt. I'm not trying to use it in some religious sense of it also. But the actual word nirukar means just *formless* and *shapeless* in a very profound sense. And something like that's going on. There's a place in this universe where things like angular momentum still share that same definition. But they're they're broken, dissected by information, and it creates this whole, a marvelous complexity that we get where we can do things like counting, where we can do things like, say, objects have a definition. You know, quaternions that took a long time, and then the hyper— I love quaternions. Quaternions, by the way… I actually would… If you notice I use quaternions when I was talking about the SU(2) symmetry.

[1:29:09] GZ: Yes.

[1:29:10] TB: It's not normally phrased in terms of quaternions and I would say that's a mistake. I'm big for Hamilton on that… I'm saying like, no! And people… So many. Phd theses have been blown on trying to make quaternions apply to physical reality, and I would simply say that, well, you need to go deeper. Don't try to equate them to space and time. That's the wrong way to do it. Go down deeper, go down to the particle level, then they start looking pretty good. And so for me, a complex number is just an encumbered quaternion. You know… It's been banged around. We're 3-dimensional, so we throw out… There's always complex planes in the quaternion sphere. So we just use pick the one that we want and I mean that in the sense that it might actually be a useful mathematical trick, it's to *stop* talking about complex length and start talking about quaternions and some of these things, like in those figures.

[1:30:08] GZ: Thank you so much. That expressed much better than what I was trying to get at, about the relationship of mathematical abstraction to the physics. Thank you again and—

[1:30:19] TB: Thank you. Thank you for bringing it up and for defending his 6th problem. It's a marvelous problem and he's a profound thinker. Incredible work… Okay, thank you… Someone asked about sterile neutrinos. Did I see that correctly?

[1:30:40] TX: Yes, they will ask.

[1:30:42] DF: Yes, I did. I asked. In fact, I asked, why you said the Higgs was the last particle of the Standard Model that was detected when the Standard Model predicts all these super Sussy particles, you know, and you didn't even mention that… You know… You present the whole Standard Model as if it's correct, and there's huge problems with it, including the sterile neutrino, including whether neutrinos have mass, all kind of things. I urge everyone to take this with a grain of salt.

[1:31:17] TB: I won't disagree. And when I say the Standard Model, do not think that I have no problem with the Standard Model. I am presenting it because historically, it was an incredibly predictive model back in the seventies, but then it locked up. And I think they'll go… and sterile neutrino is a good example. If you look at the reasons for why we have mass in the quarks and the electrons and positrons (all the fermions except the neutrino), it goes back to that issue I was talking about earlier about the partners missing. You know you have the right-handed neutrino and you have the left-handed anti-neutrino and you don't have a partner, and without that partner they travel at speed of light. That was the theory up until fairly recently. If it's massless, it travels at speed of light. And there's a whole different area I could get into that.

I'm a dual universe person, which the most recent work (Turok and Boyle) are doing some marvelous papers on dual universe models, although I, like… you know… we all have our different interpretations. But the dual universe model says that the sterile Neutrinos do exist. But, because they're unbound, they only exist in the other complementary universe to our… the contra-universe to ours. That's where… that's the only place where the full CPT symmetry comes into play. So, I'm not trying to invoke worship of the Standard Model, but I'm also saying don't disregard it, because the the symmetries it has can probably be simplified. Think of it as something you can mine, that you can look into and say, well, it's shown that something's right here, but is that really the final form

of that? And for years people tried to explore how do you unify electric and color forces and my statement is you can't, because they never broke apart, because every time you look at a quark you're seeing a unified color electric charge.

[1:33:24] DF: No one sees a quark. No one's ever seen a quark.

[1:33:27] TB: We'll never get—

[1:33:28] DF: A quark is just a theory. You know… They've got energies that they see when they try to blow protons up and they've just assigned those energies to quarks, but quarks don't exist. Okay?

[1:33:43] TB: That was a common—

[1:33:44] DF: And people say, you pull on a quark and you create another quark… All that stuff is BS.

[1:33:51] TB: The… well… the level of experimentation you can go to some of the experiments I remember most were the ones where they sent extremely high energy electrons inside of protons and they would bump off of point-like objects at those at those levels. So—

[1:34:14] DF: Listen. They're misinterpreting. They don't even know where an electron is. They're throwing electrons at stuff and watching them scatter, and they don't even have a model for an electron. So, the stuff that they're coming up with is wrong. You… you know you've got to go back to Einstein. Einstein was right, spooky action at a distance is incomplete. It's not a right theory. And he was right about the Standard Model. It's not complete, either. Well, he actually he did not say that because the Standard Model was invented after he died, but he would have never tolerated this thing.

[1:34:49] TB: And the idea of spooky action at a distance… I am in the unusual position that I am absolutely adamant speed of light applies in all cases. Shimon Perez also felt that way, that whatever is going on with that does not involve some kind of instantaneous action at a distance. That makes no sense. We have to respect Einstein's limits as rigorously as possible on everything, the math and whichever so… other questions?

[1:35:27] CP: Can I ask you a very basic question? You talk about information and in physics. So I wonder… you know… how you define this information. Is it… you know we got computational information whatever and histories or particles whatever. So I wonder if you are referring to the to the particles' property, invariance of particle properties across the whole universe. Also, we've got a different kind of of definition and also the question… in one of your slides you mentioned that the information associated with matter and then energy… and I wonder if the information is preserved in the black holes.

[1:36:14] TB: The idea of what I would define as information… persistence across time would be the key characteristic I would do. I would give an example of an atom… is a persistent form of information over time, although with some qualifications, because it has a wave function and also spreads over time. So, having many atoms together, gives you a different form of (a more stable form of) information than just one atom, but it is persistent. And without that persistence, and this is almost trivia saying it, but if you don't have persistence of some sort you can't calculate. You can't preserve the idea of a past. You can't *do* anything. You just have a universe of chaos.

So, persistence is the foundation of information. If you talk about a bit, I would say that's a more specific application of information in which you you polarize it to the extreme. You make it into a 0 or a 1, a binary choice, and then you have no other options. With that I think that's the most classical version of information, and in many ways the most powerful. It also is always a bit of an abstraction. Anyone who's actually worked with real memory devices knows, that is always an approximation. Everything has an error rate, everything has some point

at which it starts to lose that information. But we have a universe in which we enable that sufficient level that you can do a lot.

Black holes are a whole interesting issue. The most recent result on black holes that I find intriguing and revelatory is when people looked at data about stars that fell into galactic black holes. The standard perspective usually is that once a star goes into a black hole it's gone, but… which is reasonable. I mean… you say, all right… you cross the event horizon and you don't see it anymore. It's gone… until it burped up 10 years later and gave a signal that you could recognize that it was a remnant of the same star. Now think of that from two directions. First, time dilation. Yeah, that's quite a time dilation, you know, a star falling into a black hole, not showing up until 10 years later. That's about as time dilated as you get. You'd expect it to show up like a second later. But the other thing is, it didn't fall in.

This is data now. We didn't have that situation in the past. We have data now that the star didn't instantly fall in. It didn't cross the event horizon. It burped back up. And it actually wasn't just one star… The astronomer who did that, she's had work on a number of different systems and I just think that's fascinating finding. I think we're going to get more information about black holes as a result of that. But this whole information about how… this whole issue about how information works in black holes… I think is going to continue to evolve as it *has*. You can read interpretations of Black hole surfaces from 50 years ago, 30 years ago, 20 years ago, 10 years ago. They're all different. It's… saying that that's a stable area is a severe understatement… err… sphere *overstatement*. It's not stable! People keep redefining the interpretation of what goes on and this new data I think help with that.

So yeah, but too much to get into here… but black holes are a *fascinating* case, especially if you view from a sparse… Myself, I do not. I don't go for singularities. If you've seen some of my figures, I actually would describe what's going on in a black hole as an extreme magnification of space to the point where a particle can no longer exist in its interior, and the entirety of the mass is concentrated in the outer perimeter, which is more… which is actually compatible with that star finding. You can't tell from a distance. Black holes are real, but you can't tell what the internal configuration is, and I simply don't think there is a singularity there.

There's all sorts of strange paradoxes… If you have a singularity, if all the mass went into a singularity, how does it evaporate from the event horizon? What? Think about that. That actually is a paradoxical statement. If the event horizon is where the mass is at then you can have Hawking radiation. If the singularity is where… a singularity, which could be literally miles away in a galactic black hole, or maybe hundreds of miles. I don't know how big they get… How does that work? Because that that doesn't quite follow. So there's a lot of interesting issues with black holes.

[1:40:43] CP: Thank you. Thank you for your nice reply.

[1:40:47] TB: Thank you.

[1:40:50] TX: I think this is a question from Dr. Bird? He asked "Can you give me more detail about the assertion that there's nothing magic about observations and that wave collapse grace reality. I don't know how to rephrase my question more specifically.

[1:41:10] BB: Let me!

[1:41:11] TB: Nice to meet—

[1:41:11] BB: Let me phrase my question more specifically. You said that it has everything to do with the fact that linear momentum is *not* quantized. Can you clarify the connection between linear momentum not being quantized and what you said about no magic in the wave collapse.

[1:41:36] TB: Very specifically, when I say no magic in the way of collapse, I'm referring to the Wheeler interpretation that you have to have an intelligent entity at some point, that you have to have a very complex system that is involved. So any interpretation that abstracts it to a very high level… I'm saying it's… to go in the opposite direction. Go down to this momentum level. And, let's see… I think the best example that I can think of (in terms of the one slide where I showed, at the bottom of the slide… I showed light… a photon radiating…): a photon radiating from the sun. That is well known experimentally that that photon goes everywhere, because it can… There's no direction to it. You cannot get a direction to a single photon at that energy level. It's just not possible. You can do a laser beam with lots of photons, but you can't do single photons at that level.

So that single photon has a wave function (a "wave" function, whatever we want to call that, because again that's a very classical concept) that spreads out and defines how… two things… It defines how that wave can reflect or refract, in other words, behave like a wave, but it also defines the Born probability function of where it might just deposit all of its energy instantaneously. And the latter is the part that Einstein had *real* problems with, for good reason, saying like "How do you do that? How do you reconcile those two? How do you have a wave function that goes everywhere and at the same time you just have this one.

The reason I invoke momentum as the unifying background of that is the example like of a solar sail. You have that one photon coming from the sun. You have a solar sail that *coherently* reflects. Coherently is critical. The idea of coherent reflection is very important. Coherently reflects *from* that solar sail and goes back in a new direction. That is a wave collapse. There's no way around it. That is a wave collapse, because the photon that was previously potentially diffractable by a sphere the size of the sun… If you had a mirror around the entire solar system, that one photon could have been reflected back and gone back predictably to the sun. But once it hit, in particular that one mirror… That didn't happen. It stopped being that and was a wave collapse, an enormous wave collapse, enormous waves on it.

Now, you suddenly have to model this photon is two things: It's a tiny bit of momentum that's absolutely real, because this is… You see this… The Pillars of Creation, solar propelled satellites… This is real. This is not some fictional effect. It bumps it. It moves… It gives a real dose of momentum, *very small*, and with very little energy. Momentum can be transferred with almost *no* energy loss, which is also baffling. You go like "How do you do that?"… But it works out: heavier the mass, the more you can give it a little bump of momentum without depositing much energy. So there's a tiny bit of energy, but the momentum's tiny… The energy is *absolutely infinitesimal*, but both are real. So it bounces off that, so you get the momentum transfer. That's your detection. That's always going to be there. And it says, "Oh, that photon was *here*. and when that photo was there it then radiates out from *that* point and starts the whole game over again."…

Every case you'll see in physics where you have a *particle* or where you have a *photon (*it doesn't matter, any kind of particular… any kind of bundle of properties that has an energy and has an identity) it goes in little short segments. Again… The wave just goes out a little bit and… [gestures hands coming back together]… It always does that way. This is not… That's not some weird hypothesis I'm making. That's what we observe in the lab. Bubble chambers are actually a good example of that, because you're using the bubbles as detectors, and if you don't have those bubbles the same particle behaves in a very different way. It behaves as a wave. It will reflect as a wave. As long as it's got those bubbles, it does *not* behave like a wave, it behaves like a particle, the whole thing, for short segments.

So, our whole idea of a particle is based on ideas that are overgeneralizations of what we see in everyday life in our massive scales. But you… You don't see those effects. You cannot model a quantum device using that approach. You cannot think that an electron goes through one or the other slit and then continues to be a particle (which almost every YouTube video does that mistake). It doesn't. It spreads again. And if you have particles, you know, light on the other side, then it'll be more like a particle. We make our own particles. We make our own trajectories… and I think I'm drifting from your question. So…

[1:46:23] BB: I'm sorry. Say that again about the question.

[1:46:25] TB: I think I'm drifting away from the point of your question here.

[1:46:28] BB: Okay, so let me just pose another… I don't know if this is an ill-formed question… Let's imagine for a second that linear momentum is quantized. Then, how… Why would that *not* cause a wave collapse? Is… does that question make sense?

[1:46:51] TB: Well, the… Taking the extreme realism point of view, you can't make that as a hypothetical, because we don't see that. There's no case in which we see a spectrum of linear momentum in which you *must* have a particular quantity. It doesn't behave like photon reception. Photon reception is very strict. You either you get the quantum or you don't. But the same photon, when it's in wave mode, behaves with infinite (and this is what's baffling about it)… it has infinite coverage? It has infinite… indefinitely large, not infinite, indefinitely large size, under the speed of light constraint. It has indefinitely large… Oh, well, it has… definitely a large area over which it *could* impact… like in the…

I'd go back to the example. Put a spherical cell around the entire sun, out at Pluto or somewhere. Send that one photon out. There are…and you can… these are real lab experiments in smaller scales… but the idea certainly stays the same. You can make it go out there and come back and land with an extremely high probability (close to 100%) at a particular spot. And yet, if you put something out there that *absorbs* the photon, (you put a good photon absorber) some of the photons will occasionally get absorbed by that, and then all of that disappears. And this is this is not a new conundrum. This is the one that drove Einstein and Schroeder (everybody) just… you know… didn't know what to do with this. And to this day people don't know what to do with it.

So, I would just say that we need to go in some different avenues, and this idea of a shared infrastructure underneath in which there's more direct interactions going on (but that are heavily constrained) is a path to get around that, but we don't see quantized linear momentum. We see small deposits under very well-defined rules, where one photon will deposit twice its own momentum to an object when it bounces off of it. And, by the way, doesn't that sound a little strange. How does one photon impart twice its momentum when it hits an object? And the reason is that momentum can be created in pairs and you can't do that with energy. Energy cannot be created in our universe in pairs. And that's why our universe conserves energy.

Momentum can. And when momentum is creating in pairs you can do some very odd things. If you look on my *Apabistia TAO Journal*, I've got one thing where I calculate what you need to do to use one green photon bouncing back between two mirrors to impart two locomotives of momentum. And the strange thing is you can do that in principle, and of course you can't in a real experiment, but you can do it in smaller scales, because the momentum you can get with sufficiently large weights is almost indefinitely large, because you can keep creating these momentum pairs. And this violates a lot of what we tend to assume from physics, but it is straightforward physics, but it's not what you would expect if you think totally in terms of quantization of these things. the most real example is, again, solar cells.

They get twice the momentum of the photon because a momentum pair is created. You get a new momentum pair carrying the photon the opposite direction, then you get the old momentum of the photon plus a new member of the photon momentum pair going in that direction. This is one of the reasons why people think that solar sails are such a marvelous way of getting to the stars is because they use this trick. They can take the momentum trick from photons and provide indefinitely large momentum to a system.
So, a nice little quirk about momentum that we don't see with energy.

[1:50:45] BB: Thank you.

[1:50:46] TB: Thank you for the question. Anyone else?

[1:50:53] TX: Yes, I noticed there's a question earlier from YouTube: Is it possible that we've been looking at the wrong direction? What if the space is not a backdrop for objects' motion, but the space itself is moving in a spiral motion at the speed of light?

[1:51:15] TB: It's an interesting question, but I'm not sure immediately how to how to interpret this. You want to elaborate anymore? Whoever…

[1:51:25] TX: Lin, can you unmute yourself and ask the question online?

[1:51:37] TB: It's okay. It's an interesting question. It's just I… it's… there's obviously concepts and thinking behind that that I wouldn't be able to to address. So I wouldn't know exactly what that would mean. So, other questions?

[1:51:53] LB: Can you hear me?

[1:51:54] TB: Oh, yeah, Lynn… Yes.

[1:51:56] LB: Okay, yeah, I couldn't get on Zoom… I was watching through the YouTube.

[1:52:01] TB: Oh, you're on YouTube. That's right. You can't communicate directly on YouTube. Okay.

[1:52:06] LB: I'm glad I eventually got on.

[1:52:10] TB: Oh, good!

[1:52:10] LB: Anyway… Yeah… I heard what David said about this Standard Model… I agree with him. I think that there are a lot of problems with current model. So, my question is, is it possible we've been looking at wrong direction? What if the space is not just a backdrop for objects, but the space itself is moving in the spiral motion at a speed of light.

[1:52:52] TB: There are… There are models… When Dirac first came up with his positron model, there's an interesting thing about how he did that. He took the idea that there was a sea of existing particles and then you would knock one of the particles out of that. Now, if Dirac had proposed that these days people would have immediately knocked him down and said "You can't do that. You've got infinite this, infinite that… Doesn't work." but it does give… His arguments for making positrons were very much like saying there's a space of *things* and then that you add things or knock things out of it and they wind up creating new objects. So, that's the nearest I can come with it. I would just say that there are some ideas that have been around in physics since Dirac that remind me of that idea a bit.

I… Dirac described modern semiconductors with remarkable precision with his theory. His theory made no sense that I could tell from the vacuum itself and yet he had some kind of intuition where he just figured out like "Oh, okay. So you have this kind of a sea of everything's just neutralizing out then you poke things different directions, and a very accurate description of positive and negative electron and whole semiconductor physics, which is strange. I was looking at and going like "Did he know about semiconductors?"… and I don't think he did. So, if you had a space that was expanding, and… I would say space is defined by our universe's expanding outwards… Why do you say spiral? I'm curious. What's the part about spiral part?

[1:54:37] LB: I actually encountered this theory last summer. It was from a Chinese farmer… Yeah… But I just translated it into English and then during the translation, I found it fascinating. My background is in IT security, so I'm not a physicist. However, I just found his theory is… it makes so much sense. It could explain so many phenomena and—

[1:55:20] TB: One of the things I… When I give examples, for instance, about saying that the Standard Model that the U(1) symmetry, which is phrased in terms of complex numbers, and a whole bunch of concepts… is really not much more than like two bars with a spring, then you twist the spring… is not a bad model for what *all that complexity* is talking about… Maxwell, when he first started doing theories, he insisted that his theories be completely mechanical. Most people don't realize that, but he insists on having little what he called molecular vortices and using those he predicted the speed of light.

Now think about that… If you if you told somebody nowadays that you could predict the speed of light when it wasn't known at that time based on little tiny mechanical devices that look like little vortices. They're kind of cute. They're just like a honeycomb with these little devices. It's fascinating to see his early work with that. You go like "Maybe we ought to be respecting mechanical intuition a little bit more than we are."… So the fact that the guy is a farmer from whatever background… that's not the issue. The issue is do you get an insight from a particular model that you can then apply. Translation can be very difficult. I like Maxwell's emphasis on mechanical models. In fact, I guess inadvertently, without realizing it, I'm kind of going back in that direction when I say that matter is the basis, because that that gives a more material and interpretation of that so… interesting.

[1:56:58] LB: Yeah, this theory I have read. It suggests space is moving in a spiral in three dimensional orthogonal matter fashion… What word is accurate to describe it?

[1:57:23] TB: Did you know that our universe is left-handed?

[1:57:28] LB: In this theory actually it says right-handed.

[1:57:33] TB: Well which convention you use is actually a matter of choice, but at the particle level… Remember, I talked about those particles, how they come in pairs? We have a profound bias towards the right-handed… to the left-handed side from the matter particles, because we have an imbalance of matter and antimatter. So we do have a chirality in our universe. It's a left-handed chirality. So it's a left-handed spiral… Now, it's part… it's… It's broken up into little tiny vortices at the particle level. So, but that actually just… that's well established and there are also theories and relative… different… I've seen one once where there's some theory where they talked about the rotations of space. That's an older idea. It goes back decades. So ideas like that… There are ideas like that out there.

That… It may have been Godel who had some… Godel had some very interesting interpretations of Einstein's equations… that there… he was intentionally kind of stretching the model and stressing it to see what he could come up with. So Godel liked to do things in a very different way and that was an example of that. He took Einstein's equations and took them in a very different direction from there. So again, interesting.

[1:58:48] LB: Yeah, with this theory, actually, it could explain a phenomenon such as dark energy, dark matter… because it believes that the universe, no matter [whether] it is cosmic or atomic [or] subatomic even… They all follow the same rules, so when we think of the… and also it suggests matter is the disturbance of the motion itself. If the motion is uninterrupted, it would not matter, and the time is the count of the emergence, in radial direction. So that is… that actually corresponds to Einstein's time and space. It is equal. It is one thing, the same thing. The displacement on the radial direction is the time; the count of the displacement is a time. So they are the same thing. It says it's 3-dimensional. Another is a tangential… On the tangential it represents the speed.

So… the spiral… When you… when the spiral is moving in the radial, if it is one tick of the time… On the tangential it would be a half circle… half circle: $2\pi r$, $r = 1$… then half… it would be π. So that is the light speed in this framework, if without any interruption. And then it also has the torsional direction. In the torsional direction it is a full turn, a circle. That is a charge. That represents the charge. The full circle represents the charge. That's why it is discrete. So you cannot have a half… a turn… on the torsional direction.

That is how we observe this discreteness. And also because it is a spiral motion it has a surface area. Surface area is π… πr^2. The… So, when r is one, the surface area is just π, but when the time goes… Like two… when the time is two, it become four… $2^2 = 4$… So it becomes 4π. That is the action actually. So that's why the universe is expanding. It is not… Although the speed itself is constant, the action actually it is… it is expanding. When time ticker is larger, it is… [incomprehensible audio]… Yeah. So that's… That's why. And then, when we talk about dark matter, dark energy… It is the… It is just the same motion. When we… when we do not realize the space itself is moving and we imagine something costed… so we call it dark energy or dark matter… mysterious, but it is not. It is the same space, the same motion. When it… when it is away from the center point, it is essence… Extended extent—

[2:03:24] TB: Lynn, I think—

[2:03:25] LB: Yes—

[2:03:26] TB: In the comments… I ask if you could send a link or a document. So I think people interested in that could take a look at that, because obviously… it would… he's got a whole little theory. But if you could put a link to some of that, the people who are interested could follow more information about that. It sounds like he's read at least pieces of some of the physics of fermions and bosons. I'm just guessing again.

[2:03:56] LB: Yeah, yeah. He wrote—

[2:03:59] TB: [incomprehensible audio] some ideas that you might have gotten from that. But if you could share a link in that… in the comments, I think that would help anybody interested to look it up there.

[2:04:07] LB: Yeah, actually, I have basically other two people written a paper recently. We just submitted to SSRN and it's a… we just submitted. So it's not published yet. We don't know if it's going to be rejected, because none of us—

[2:04:30] TB: Even if it's… you know… you could post bits of what you have on your thoughts online. You don't want to mess up your paper submission. But… and if it is rejected you can always just publish it yourself. The internet's a free place to do that. But if you have any links that you could give people a little information or interests—

[2:04:48] LB: Okay, I could. I could send something and—

[2:04:53] TB: Any other questions from anybody.

[2:04:57] TX: George has a question.
Could the Kolmogorov folks student Khinchin be the Russian mathematician you were referring to?
He wrote on probability information theory.

[2:05:09] TB: What was the name again?

[2:05:12] TX: The Kolmogorov.

[2:05:14] TB: Absolutely! I love his work. To me, he's just… he's the guy who did some of the *most* interesting work about information theory… Kolmogorov… his complexity. And it's got a heuristic aspect to it that fits very well with ideas like data compression and computer science… That there always could be a way to compress something incredibly, you just don't know it. You throw all the figures of π in a pot. You say "Oh, gosh! There's no way I can compress that. That's just raw data."… until somebody shows you the equation for generating pi and then suddenly it's compressed by essentially infinitely. So Kolmogorov dealt with issues like that and had other interesting works, but I just found his perspective on information kind of more profound in some cases, whereas

von Neumann, I think, was a little more pragmatic on some of it, but both just fascinating bits of work on information emerging.

And I keep going back to it. You know, I would say that information is the ability to create *persistent* information, which starts with fermions, because if you don't have fermions… Photons alone you can't make *persistent* information. You can make a big ball of plasma or something, but you can't get things that actually have continuity over time. So without that, you know, the universe gets very, very boring and it's not hot. So, cool concepts and quite recent, like I said, just information was not even a concept in the last century.

You know… it's when first people started really honing in on that. And my two cents on that is always the thing like "*And* it requires matter and energy, you know."… Don't just invoke information and say "Oh, I can just put it where I want to in space. I can put it in a black hole."… *No!* Well, a black hole at least has mass and energy, but… Look experimentally. Experimentally you don't see any mass and energy. It's a pretty good heuristic to say "Maybe I shouldn't be assuming that."… and if you go through the whole special relativity arguments about the fact that every time you invoke a foam, a substance, and it is just… even if it's not a popular view, it just… You can't get around the math on it. You wind up with a single relative… a single non-relativistic frame. Whose frame is that? You know… that… the whole idea is that special relativity says there is *no* special frame, so I think that's a good point.

Kolmogorov. Anybody who has never heard of him… He's worth looking up. Great, great fellow!

[2:08:03] GZ: Thank you.

[2:08:05] TB: Thank you.

[2:08:09] CP: Comment that… following Lynn's comments… and also Dave mentioned on the chat there… about the theory… about spiral expansion of the universe… Is that?… It would be nice to hear your opinions as well as Dave's, about this galaxy's motion, which is a spiral. It would seem that all these galaxies in the universe, they are rotating in the same directions. Would that possibility connect this theory of spiraling, expanding universe.?

[2:08:52] TB: There was… There was some work… I remember seeing the paper a couple years ago about whether there was a preponderance of a certain type of spin in a galaxy, and at first I'm not quite sure how that's measured. There would have to be a common axis, because if they're just, you know, in random directions you don't get that. But there did seem to be some papers where they were suggesting that there was an overall bias, essentially an average angular momentum that was non-zero, is my best recollection, because I say it was a paper some time ago. Then I saw some other papers where they were less sure about that. So I haven't followed up on that, but that was a very interesting finding, and I'm just… keep wondering… actually, I may try to look that up later and see what it was—

[2:09:35] DF: That… I know where that came from. There was a study where they asked people to look out at all the galaxies… you know… and characterize them. Which way are they spinning? And they did that, and it was biased. Then they flipped. You know… they just flipped the direction of the space… you know… like looking at the galaxies from the other direction, right? And there was still a bias. So they really felt that… I mean, if you just looked at it one way and say, "Oh, there seems to be more in one direction."… You could say "Well, you're just… your right-handed eye or whatever is *imagining* that there is more right-handed or left-handed."… But no, they flipped it, and the effect was still there. I think Sabine maybe covered this, or maybe Dr. Becky. I've seen—

[2:10:29] TB: David, do you happen to have a reference for the paper? I'm sure I can find it somewhere, but now you got me curious. I do want to look that up, to see if… cause I remember encountering… but it was years ago. It was quite a while back, but if you happen to have a reference on that you could put it in the comments.

[2:10:42] DF: I saw this fairly recently, and it came from some of this study. So citizen scientists are out there busy characterizing galaxies… you know… shapes and stuff like that. You're given us a set of pictures of the universe, and people are going in and characterizing stuff and I believe that's recently where it came from.

[2:11:07] TB: I do think that there is more to spin and its relationships in the universe as a whole than we understand. If you look at the large structure of the universe that's emerged over the last 10 years… Have you seen some of those pictures? They're astonishing! They're gigantic!

[2:11:27] DF: It's—

[2:11:28] TB: … fiber bundles—

[2:11:29] DF: Yeah, it's not isotropic, and there's structures—

[2:11:33] TB: Yeah. It's absolutely nothing like what Einstein predicted. and people just keep… but it just isn't. I mean Einstein, and pertaining to isotropy and all that… And boy that's not worth seeing, especially those bundles, those filaments of galaxy clusters, and they have spins (by speaking out for Lynn, for your idea), those… there's… an animation I saw showing the motions of some of these enormous structures and they're spinning, and you look at that and go like "What the heck is going on there and why?"… and things are being pulled into it.

So these are levels of complexity that… you can use the dark matter to… most of the dark matter theories are piles of parameters that just say "Oh, we got a new observation. Put another parameter."… That's not a terribly persuasive way to to model something that's supposed to explain it, and that's been the history of dark matter pretty much since the get go, is that "Just keep adding parameters and keep doing form fitting."… So it's kind of like the the chatbot approach of just… you know… keep adapting to whatever you see until you get it.

But these structures… I just… and now I will give my 2 cents on it… is that… Since I think that matter creates what we think of as space and time, when you push it too far, things start getting stringy. It's like taking a bit of dough or just pulling it out and it starts breaking into pieces… or strands. My intuition (nothing more, not even a theory but just my intuition) is that that kind of looks like what's happening on the galactic scales… it's that we're stretching the matter contents so much that you get giant voids that form that have absolutely nothing in them, just like you would if you were stretching some kind of dough… you know… It… There's only so much dough. It only stretches so far, then you start getting lower dimensional structures in that dough, and then you have these spinning issues attached too.

So, there's more going on there… Before plate tectonics took off in the well… in the sixties in most of the world… and in the seventies in the US… The US was slow on that… It didn't matter how many times people looked at the map of the Americas and Africa and said "Hey, those fit together almost perfectly."… and people would just shrug it off and say "Well, yeah, just a coincidence."… and it's sort of the same kind of thing that goes on with these gigantic cosmic structures. We have all these filaments and structures that are completely unpredictable by general relativity. People just keep saying "Oh, well, you know, that's just the way it is."… and probably *not*. Probably we're *missing* something fairly important and we just haven't quite got that yet.

So, I've already stated my pretty radical opinion that I think even gravity itself is a remnant of the process of creating space and time at multiple levels of scale, because these inertial frames have multiple scales. You have gigantic inertial frames, smaller ones… they're all in a kind of a fractal network, but they're fractal. They're not… It's not continuous space, and so that would be where I would go with that or say, like "Yeah…. you know… you stretch this model so far and the matter… You're running out of dough. You're running out of material. You're going to get different behaviors that don't follow the nice isotropy that you get at smaller scales."…

Solar systems scale totally isotropic. We have, you know, a nice level of isotropy. Get up to the galaxy? Things start getting weird… you know… and why are these things behaving so oddly? Get up to the galactic structures, the large ones, and then who knows what? None of that could have been predicted. There is not a physicist in the world who would have predicted these gigantic structures. Everybody just assumed "Yeah, it's gonna be simple."… So, there's still plenty of physics out there and this is one of the areas.

Other questions?

[2:15:47] TX: Yes, Lotus Ron has a question: If the entire observable universe was rotating, how could we know.

[2:15:58] TB: Well, for one thing, how do you know if you're in a spaceship and… or… you're in a space suit and you stick your arms out and you feel a pull on them. How do you know you're rotating? Centrifugal [centripetal?] force. Let's assume that you can't see anything. There's no visible… you know… But all you have to do is… you're spinning in a container by yourself… If there are centrifugal forces you're spinning. So, there actually is a way that you can define the entire universe… And there's some…. There's some old ideas about this. This is… The idea of a spinning universe actually is not new. It's just… it's not popular.

It was popular, what, 50–60 years ago. But the idea of a spinning universe would imply centrifugal force and that would show up on, for instance, these galactic structures we're talking about, or that bias, the idea that you have galaxies biased, If that's a real… if that's a verified finding, that is a net angular momentum and that means that region of space itself has angular momentum and is in some sense spinning… or not "in some sense"… It *is* spinning. So yeah, you can define spinning based on centrifugal force, even without a reference point, which is really weird. I think that's fascinating.

This is Mach's principle again. That… how do you term spinning? If you… the strict Mach's principle… that can't happen… because they say that spinning is only relative to the universe. But if you go to a *dual* universe model, which I'm a fan of, then you can easily have spin in *both* universes, *because* they spin relative to each other. But you can't see the other universe; it's going off the wrong direction. So, fascinating set of topics that, and yeah, you could… These galaxy findings may be an indication of just that. Let's see, David said "Just like the Standard Model."… I don't know. Did you want to elaborate Dave on why… I didn't catch the conversation before that.

[2:18:03] DF: I was answering Ron's question about the universe spinning, and he says "Oh, it's just speculation." and I said "Yes."—

[2:18:14] TB: [laughs]—

[2:18:15] DF: Just like the Standard Model is *speculation*. Just like all these theories are speculation.

[2:18:21] TB: Well… you know… when I talk about realism, I can talk about a version of realism that fully accommodates you if you're a solipsist, which is this: if you see persistent patterns where if you do a certain set of things and you keep getting the same result then if that's your definition of what is a *real* result… And my point I like to make is you can be a solipsist and that's still fine. You're just saying that your world, that you're the only one in it, has a set of rules and you can observe the rules and rep that thing. My point about realism is mostly just: be really careful about the elaborations.

On the case of… you know… like whether quarks are real… Oh… Skepticism… In fact, many of the physicists did not believe… Feynman did not believe that quarks were real for quite a while. Of course, he had his argument going on with his office mate, Gilman. So they were always at odds on things.
So… but you do have data, and the data part of that is the findings that you have extremely high acceleration rates… you get certain patterns of what you get out of it. Obviously, you have to have *some* way of interpreting that data, but there can be different ways of interpreting that, but you don't want to discard the actual data. There

is data that shows, just like the nucleus of the atom was first indicated by having [incomprehensible audio], the nucleus of the atoms was first indicated by alpha particles reflecting off of some very hard little object in the middle of an atom. *That* was unexpected, and these results that they got with the electrons (very high energy electrons) injected into nuclei was very similar to that. So, I wouldn't just… I wouldn't just throw toss off a result like that. You still have to explain it somehow, and that's part of realizing where I think—

[2:20:19] DF: I agree it has to be explained, but the problem is they're explaining with a point particle view of it. They imagine they're sending the electron as a point particle, and we know the electron has the magnetic field around it, but they imagine that they're sending a point particle and then hitting something and bouncing out. So they're… So all that stuff about momentum and all the quarks moving in there… I mean, they actually think they can find a top quark when they do this stuff. They just *do not know* what they're doing with an electron—

[2:20:53] TB: When you do those kind of injections, in defense on the point about what they're doing, they don't view it as a point either. In fact, they're very specific…The models do not allow you to treat it as a point. They treat it as an area and the area gets tighter as you go in higher velocities. So the models are not that trivial? They're not so trivial that they just assume a point is there. They talk about… one of my favorite metrics… What is it? one barn is… can't hit the side of a barn… So they talk about how many barns a particular nucleus might be… So… This guy… I understand skepticism, but I wouldn't trivialize how they do the models. Take a look at the models sometimes because it gets quite detailed and they do find results that are not expected—

[2:21:45] DF: If they don't model the electron as an electromagnetic *entity* that reacts with the proton electromagnetically, then they don't have the right model. Okay? They can't. You've got to know what a photon is. You've got to know what an electron is. You've got to know what a proton is before you start using that stuff to try to figure out what's inside a proton. All right? And this thing about quarks… people talk like they're real. They're not real. All we do is detect *the energy* and the energy is a photon energy. It's not a quark. We're detecting the *energy* of this quark or whatever it is that is disintegrating in… I don't know… 10 to the minus 50 seconds or something… It just doesn't last long. All they detect is the energy that comes from this thing collapsing, whatever this thing is.

[2:22:49] TB: Yeah, when they extend… The quark experiments you're talking about are the *real* origins of string theory. They talk about string theory these days. That's a whole different kind of string theory, but the models that they found, and the mathematical relationships between masses were the original string theory, and what they found was if you hit something like a proton hard enough you never get a quark. You never get a quark. So people talked about… I remember the period where people were searching for quarks and never finding them. They look and they say "Well, we don't… We don't get any quarks."…

[2:23:29] DF: Well, keep in mind you don't… You don't detect a quark.

[2:23:32] TB: Yeah—

[2:23:33] DF: You detect the energy that *was* the quark. Okay? You detect the electromagnetic energy, the *photon* that comes out of it. That's what they do in *all* of this stuff when they're jamming protons together at CERN. They… All their detectors are *this universe*, this… All their detectors are built out of our protons and our electrons and stuff. So everything that you see, everything that they detect is some wave that has come in and detected in the mass that we know of.

[2:24:18] LB: Actually, yeah—

[2:24:19] DF: We don't detect muons either by the way. Muons come in and slam into the atmosphere and you detect the *result* of muons hitting other stuff.

[2:24:30] TB: Yes. Well, the generation of… What actually happens… You get a… Something hits the top of the atmosphere and you get a shot—

[2:24:39] DF: Yeah… You get a scattering of *other stuff* where that energy goes into other *real particles* that we have here *in our lives* and then emits some type of energy, electromagnetic energy: what we call photons, sometimes.

[2:24:58] LB: Right, yeah. I believe that. Exactly. That's why this theory I was talking about to demystify all those mysteries. Yeah, it is just energy, but when you detect it, it is… We use that function, mv, that v, in this theory, it would be mc - v, because that c is space… speed… You have to use the c – v [to] get the *actual* amount of energy you can detect. So that explains a lot of phenomena: Why the experiments gets far, far away from prediction, because currently people do not consider the speed of space itself and everything related to it, including the momentum. If you do not consider that *default* space speed, you only use p = mv. You ignore the c… then you don't get the actual accurate prediction.

[2:26:19] TB: Lynn… You're aware that the most models in physics do model time as matter going forward at the speed of light in the universe, are you? Have you? Are you aware of that one?

[2:26:33] LB: Yeah, yes, yes. Yeah. Right. Yeah, yes. That is—

[2:26:38] TB: [incomprehensible audio] move forward in time… and that… when you—

[2:26:41] LB: Right, right. That is yes—

[2:26:45] TB: By the way, David, do you actually believe in muons or not?

[2:26:49] DF: Oh, no, I believe in muons. I believe in some stuff that… that you don't believe in, hahaha. But—

[2:26:55] TB: But you believe in—

[2:26:56] DF: But no, I believe in muons and tauons and whatnot, but I see them *differently* than most people do.

[2:27:04] TB: Okay.

[2:27:05] DF: And they can't… They can't exist for only a *short* period of time in *our* proton-electron world. So our proton-electron world has a certain *energy* that it lives in, right? The only way *we* detect is in… is by what protons and electrons are reacting to these other particles.

[2:27:31] TB: Don't forget neutrons though. I assume you have neutrons in there.

[2:27:35] DF: I have neutrons, but I don't… I actually have protons and electrons as neutrons, okay? So yeah, neutrons are not… neutrons do not… Hey, hey! You're not last either. Neutrons do not exist outside the nucleus, okay, except for a short period of time.

[2:27:53] LB: My suggestion—

[2:27:55] TB: Yeah—

[2:27:56] LB: My suggestion: I would present my paper here. I don't mind. I just do not… I'm not a physicist. I've never submitted a scientific paper before. I do not know if it's appropriate to present to my paper here, but I was already submitted… I've already submitted to… actually… I don't know if I... yeah, I… yeah… I have submitted to Physical Review. I know it's very ambitious, but what the heck and most [likely] it will be rejected.

[2:28:38] TB: Well, of course if you don't try you don't know… David, on the model that you mentioned about the electrons and the protons in a very tight relationship… that actually was the very first model of neutrons… that it was… I can't remember which physicist suggested that, but he suggested that there was some special extremely close relationship between—

[2:28:58] DF: There's a number of people who still believe that.

[2:29:00] TB: Yeah, I'm not one of them. So—

[2:29:03] TB: I got a balk on that one… So, I'm willing to explore it, but—

[2:29:07] DF: But yeah… I don't… I don't even believe in charge. Okay? So I'm—

[2:29:10] TB: I'm gathering that so…

[2:29:13] DF: I mean how can you have positive and negative and they come together and then there's something… you know… positive and negative means 0, right? So this whole idea of charge is misdirected.

[2:29:24] TB: Do you believe in positrons?

[2:29:25] DF: Huh?

[2:29:26] TB: Do you believe in positrons?

[2:29:28] DF: Yes, of course.

[2:29:29] TB: Okay, well, the positrons and electrons can come together and go boom!

[2:29:33] DF: Yes, they can.

[2:29:35] TB: So, why do you say you don't believe in charge.

[2:29:40] DF: I don't believe in charge the way it's *described*. For instance, the electron is attracted to the proton, right? The proton's positive. Then why doesn't the electron just go in to the proton and just go right inside of it? Why doesn't it do that? You have to understand about the structure of that electron, the structure of the proton, to understand why electrons go around protons, *possibly*. All right. I know about orbitals, but you have to understand what you're dealing with… you know… physically… and they don't have that. They just have equations. Equations are not a physical entity.

[2:30:29] TB: They have equations.
There's a lot of experimental data behind some of those equations, particularly on the issue about electrons binding directly to protons closer than a hydrogen atom. And there are different—

[2:30:42] DF: You mean muons binding—

[2:30:44] TB: Four muons [incomprehensible audio]—

[2:30:45] DF: —closer to a proton—

[2:30:46] TB: —Muons causing fusion because muons are 200 times heavier. They're great fusion catalysts, which is a very real effect, so you can see that, and if electrons could bind that tightly to a proton, they would

induce fusion, which is something, again, we don't see. So if your hydrogen suddenly collapsed into a proton-size neutron, then—

[2:31:06] DF: It's a whole different paradigm that I'm talking about. So yeah, I know what you're saying, I know what they say, and I'm on to *something else,* okay?

[2:31:15] TB: Okay… You should… The same thing, I said to Lynn… You should share a link and let people (if they're interested) take a look at what you're talking about. Any other questions? We're getting…

[2:31:35] TX: Yeah, Terry. Do you have more new topics after September?

[2:31:42] TB: Oh, one of the… September?… The topic I would… Let me tell you… I was thinking about the Yang-Mills Prize… Talking about the Yang-Mills Prize… That would be a little bit on the same topic, but I could expand on some of that.

[2:31:58] TX: Sure.

[2:31:59] TB: But you know I… It's a million-dollar prize sitting out there. Nobody's won it. I could give you a deep elaboration about what has been said about it, what hasn't been said about it, why there are problems with doing it… First of all, it probably shouldn't have been a challenge in the first place. It's a little too physics-y, but still it's an interesting challenge and it does deal with these symmetry groups and you know… So, I think for October that'll be a talk about how to win a million-dollar prize.

[2:32:30] TX: Sure.

[2:32:31] TB: Good luck on winning it, because it'll take you at least ten years to get it, but maybe you can solve the problem. So I think it's a good challenge from that side. That will be October.

[2:32:42] TX: Sure. Thank you.

[2:32:42] TB: Okay, thank you. Anybody else? I think we're about a wrap then.

[2:32:53] TX: Yeah, and remember, next week we will have another meeting with Dr. Carla at 3 pm Eastern Time.
So that'd be noon on the Pacific Time.

[2:33:05] DF: Thanks, Terry, as much as I disagree with the Standard Model. I appreciate it—

[2:33:08] TB: I enjoy your dialogue, seriously. I just get tired of physics being so stuffy about saying, "Oh, no, it has to be this way!"… and *gosh* we shouldn't be doing that. We should be talking about…. well, maybe the whole idea is wrong… you know… because I don't think we make progress if we don't do that. So we don't have to agree on things, but let's explore some.

[2:33:30] DF: I agree.

[2:33:31] TB: Well, thanks, everybody.

[2:33:32] DF: Thanks.

[2:33:33] TB: And they've enjoyed the dialogue… Thank you, Barry.