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What is Time? Stephen Wolfram's Groundbreaking New Theory

Co je čas?

Dr Brian Keating

307 tis. odběratelů

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Co je čas? Přelomová nová teorie **Stephena Wolframa** s.wolfram@wolfram.com

doktor Brian Keating 307 tis. odběratelů 381 652 zhlédnutí 2. 12. 2024 Celovečerní epizody Briana Keatinga Into The Impossible Podcast.

Win a meteorite✹! Join my email list: http://briankeating.com/yt what is time? Is it just a ticking clock, or is it something deeper? In this thought-provoking episode of Into the Impossible, **Stephen Wolfram** , questions everything we know about time, I finished reading it and the statement is a lie! and offers a revolutionary computational perspective that could change how we understand the universe forever. That's a lie too, he offers nothing of the sort. Stephen Wolfram is a computer scientist, physicist, and businessman. He is the founder and CEO of Wolfram Research and the creator of Mathematica, Wolfram Alpha, and the Wolfram Language. His language is terrifying… For 4 decades, he has pioneered the development and application of computational thinking. He has been responsible for many discoveries, inventions, and innovations in science, he didn't give them away, technology, and business. He argues that time is an inevitable progression in computation in the universe, and the frog is also an inevitable progression (without computation)… where simple rules can lead to complex behavior. This concept, called computational irreducibility, means that time has a rigid structure ?? He hasn't explained 'why' this either, (rigidity = strictness, austerity) and that our perception is limited by our computational capabilities. Wolfram also explores the relationship between time, space, and gravity,?? suggesting that dark matter could be a feature of the structure of the universe. Tune in and discover the true nature of time.

0:00
(01)- Time is really not just like space time is a very different phenomenon from space. the fact that relativity emerges as this connection between space and time is something that is kind of an emergent thing. It's not something that is intrinsic to the nature of space or the nature of time. time, I think, can be thought of as the sort of inexorable progress of computation in the universe. Stephen, the thing that always comes up, when we talk about these three subjects time, life and consciousness, nobody can define it. Nobody ever gives me a satisfactory definition that those three, you know, people in those fields can agree upon. And therefore I think it's kind of bunk. But today we're going to delve into how we can actually understand what time is intrinsically, as you say. But also apply it to our field, my field, cosmic microwave background. It's temperature and polarization. So, Stephen, how are you doing today? I'm doing well. Thank you. the first thing I want to ask you about is, is, is what time is to

The true nature of time

you versus what it is to the general listening layperson. We have the brightest audience in the known multiverse.
1:02
But the question is, we all sort of. It's kind of like the old Supreme Court definition of pornography, you know. You know it when you see it. But I'd like to connect it both with your physics project and with my Simons Array project. that's for you to actually do what you do uniquely well, which is to make things that are very complex, utterly understandable, but preserve the fascination. So, Stephen, yes, the recent article starts with this deceptively simple but really profound question. Time is a central feature of human experience, but what actually is it? What are you suggesting in this? To me? Revolutionary new monograph. What is time? People? People will say. Well, we can say it's now. It's some time in the future. We think of time as like a position. We say, you know, we have a clock and we're looking at a smartphone or whatever, and it reads a certain time and it feels a lot like we're just saying where we are and some thing where we can be moving through it. The thing that's a bit odd about time immediately is unlike space,
2:04
where most of the time we're just in one place in space. So we think of ourselves as being in one place in space, and we kind of have to decide to move to another place in space. Time doesn't work that way. Time inexorably moves forward for us. So that's that's the first kind of thing which kind of distinguishes it from space. I think one of the things that sort of happened in 20th century physics, as a result of some of the technicality of relativity, is people got the idea. Space and time are the same kind of thing. And that was a kind of actually Einstein, I don't think really thought that. I think, Minkowski, mathematician who kind of came to sort of, clean up the mathematics of special relativity. By 1909 or so was saying, well, we noticed that we have these expressions for proper time for, for space time distance. That's x squared minus t squared. And that reminds him of these things in mathematics quadratic forms.
3:01
And so let's just think of time as being a coordinate just like space. And that's kind of where the whole notion of time is just like space came from. think that time is really not just like space time is a very different phenomenon from space. And the fact that relativity emerges as

this connection between space and time is something that is kind of an emergent thing. It's not something that is intrinsic to the nature of space or the nature of time. the place to start and understanding time. And it's in a sense very unsurprising once you kind of see what what's going on is time, I think, can be thought of as the sort of inexorable progress of computation in the universe. So what does that mean? Well, let's say we just define rules for some system. Might be a system of black and white squares, might be some, set of graphs that connect different, different nodes together. But it's just some rule that says whenever you see a configuration

4:02

that looks like this, replaced it by a configuration that looks like that can be a very simple rule, but you keep applying it wherever it might apply, you apply it. You keep on doing that. And the thing that then happens, the big surprise that I kind of discovered in the early 1980s is even when the rules that you put in a very simple the behavior that you got out maybe very complicated, that's something that's really not. It took me a while to kind of adapt to that intuition that you know, you think from doing engineering things like that. If you want to

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(01)- Time is really not just like spacetime is a very different phenomenon than the universe. The fact that relativity emerges as this connection between space and time is something that is something that emerges. It's not something that's inherent in the nature of space or the nature of time. I think you can think of time as a kind of inexorable progression of computation in the universe. I've only read two sentences of the text and I can already see that this is going to be a big slog. Stephen, the thing that always comes up when we talk about these three subjects time, life and consciousness, nobody can define it. Nobody can ever give me a satisfactory definition that these three, you know, people in these fields can agree on. And that's why I think it's a bit of a bunk. But today we're going to dive into how we can actually understand what time is, as you say. The folk concepts, perceptions, and needs to "work time into human terms" are fundamentally different from the concept of time in physics and the fields next to it, i.e., astrophysics and cosmology... But apply it also to our field, my field, the cosmic microwave background. It's temperature and polarization. So, Stephen, how are you today? I'm fine. Thank you. The first thing I want to ask you is **what is time**. The true nature of time to you versus what it is to the average lay listener. We have the clearest audience in the known multiverse.

1:02

But the question is, all of us kind of. It's kind of like the old definition of pornography. The Supreme Court, you know. You know it when you see it. ?? I didn't get it. But I'd like to connect it to both your physics project and my **Simons Array** project. This is for you to actually do what you do uniquely well, which is to do things that are very complex, perfectly understandable, but still fascinating. So, Stephen, yes, the recent article begins with this seemingly simple but really profound question. Time is a central feature of human experience, but what is it? It is a physical quantity. Existence. (And it also has three dimensions like space, which should be an interest of science to explore). It is even "matter-forming." The explanation is in other articles about it. What are you proposing in this? To me? A new revolutionary monograph. What is time? People? People will say. Well, we can say now. It is some time in the future. You are no longer talking about time as a quantity, but about a perception: the flow of time. It is not the same thing. We perceive time as a position. Well..,

well O.K. We say, you know, we have a clock and we look at a smartphone or whatever, and it shows a certain time you are talking about the flow, the passage of time again, which is a phenomenon that "appears" when an object (material and immaterial = cursor) moves along the time dimension and thereby cuts intervals in that dimension... and it is a lot like we are just saying where we are and where we can move. Time already in its usability has its dimensions, three dimensions. (Later I will explain 'why' three dimensions). Then the continuum of 3+3 dimensions is space-time as an environment in which people live, and not only people. It is an environment "for everything that is in the universe, in our universe". And even that space-time is the "building block" from which matter is built, and the physical field, and other other "things." The thing that is a little strange about instantaneous time is not like space,
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where we are most of the time in one place in the universe. So we think that we are in one place in the universe, we think so because it seems that way to us (until we realize that it is not so), and somehow we have to decide to move to another place in the universe. Most of the time we don't even have to decide about it, because the "moving to another place" is done for us by the Universe itself (+ its laws). Time doesn't work like that. Time moves inexorably forward for us. The pace of time "goes forward" due to the UNPACKING of dimensions (both time and length), on the scale of the macrocosm. On the scale of Planck scales, time can go both forward and backward, because the environment here is in a way a "boiling vacuum, foam of dimensions" and so this state is linear. Whereas the state of space-time behavior on the macroscale is nonlinear. I think it is a state of parabolic curvature. In the microworld, space-time is packed (and unpacked) into packages = balls, which then have a function and behavior like matter, it is matter, elementary particles that conglomerate into more complex states (atoms, molecules, compounds, chemistry, biology up to… DNA) https://www.hypothesis-of-universe.com/index.php?nav=e . So that is the first thing that distinguishes it from the universe. ?? I think that one of the things that kind of happened in 20th century physics, as a result of some technical issues of relativity, is that people got an idea. We know that animals don't have ideas… Space and time are the same thing. (As if time were antispace and space was antitime three-dimensional, which we can call "time"). And that was actually a kind of Einstein, I don't think it was. I mean, Minkowski, a mathematician who kind of figured out how to clean up the mathematics of the special theory of relativity. Around 1909, it was said, well, we noticed that we have these expressions for the right time, for the space-time distance. That's x squared minus t squared. $x_2 – t_2$ And that reminds him of these things in mathematical quadratic forms.
3:01
So let's think of time as a coordinate just like space. https://www.hypothesis-of-universe.com/docs/c/c_486.jpg And that's kind of where the whole concept of time is the same as space. I think time is really not just like spacetime is a very different phenomenon than the universe. That's a stupid perception..., of course, time is not the same as the Universe. The universe itself is a state realized from the two quantities Length and Time, where then matter is realized from the dimensions 3+3 of those two quantities. https://www.hypothesis-of-universe.com/index.php?nav=ea And the fact that relativity appears as this connection between space and time, that's a stupid understanding; relativity does not appear "as" the connection of space and time…; even where space is connected to time, relativity does not have to be and is not… is something that is something that appears. :–) It's not something that is inherent in the nature of space or the nature of time. The place to start and understand

time. And it's very unsurprising in a sense, once you see what's happening, is time, I think it can be considered a kind of inexorable progress in calculations in the universe. ? blah-blah. So what does that mean? Well, let's say we're just defining rules for some system. You define rules?? And you get what?, progress in calculations?? I don't understand what you're saying... It could be a system of black and white squares, it could be some set of graphs that connect different, different nodes together. What "it"? But it's just some rule that says, whenever you see a configuration
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that looks like this, replace it with a configuration that looks like this, it could be a very simple rule, but you're going to use it, wherever it might apply, apply it. I don't get it yet. You keep doing it. And the thing that happens then, the big surprise that I kind of discovered You discovered the 'surprise' ?? in the early 80s, is that even though the rules that you put into the very simple behavior that you got can be very complicated, that's something that it's not really. Ah, simple rules are complicated and that's not really... It took me a while to adapt to that intuition, you know, you mean when you're doing like, what?? engineering stuff. If you want

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(02)- make a complicated thing, you have to have complicated rules to set that thing up. But it turns out that in the computational universe, that's just not true. It's kind of like you can take sort of a computation and use it as kind of a telescope to look into this computational universe. And sort of the first thing you see is this phenomenon that even when your rules, your program is very simple, the behavior you get maybe very complicated.
5:02
Okay. How does that relate to time? Well, there's a very important phenomenon that's the result of this fact that even very simple rules lead to very complicated behavior. And in the end, it's this phenomenon I call computational irreducibility. So here's how this works. So in traditional science, particularly physics, one's used to the idea, oh let's find the fundamental laws, the fundamental rules by which some system operates. And then we're kind of done because we kind of imagine once we've got those laws, we might represent them mathematically. We can just essentially write down a formula for what the system is going to do. So we can just say immediately, this is what's going to happen in the system. We can make predictions about what's going to happen in the system, where we can use our formula to see what the system is going to do. And that's much easier than the sort of computational effort the system has to go to to do what it does. So typical example of this, the two body problem. in celestial mechanics you have an idealized sun, an idealized earth.
6:05
And you have these equations that describe the motion of the idealized Earth around the idealized sun. And those equations, we can just write down a formula for the solution to those equations. So if you want to know where's the earth going to be a million years from now, you don't have to trace a million orbits. You can just say, I'm going to plug the number of million into my formula and immediately get the answer that's been the thing that we sort of hope for in a lot of kind of traditional science. We hope for these kinds of computational reduce stability predictions. Well, turns out that out in the computational universe, there's a lot of systems that don't show that kind of reducible. I'd say they show computational irreducibility. They show a phenomenon where you can if you want to say, what's the system going to do after a million applications of this rule? Well, you can run those million applications of the

rule and see what the system does. But it turns out that's sort of an irreducible computation. You can't find a way to kind of jump ahead and say,

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I know what's going to happen. It's going to come out with answer 34 or something. just have to follow the steps to see what happens. And so that's kind of a it's a from sort of the point of view of, of kind of how to think about science. It's a significant thing because it kind of says that there are limitations to science that arise kind of within science itself. There are things where you can't just say, we've got it. We know the answer immediately. And, you know, I think one thing to understand about computational irreducibility, which is you might say, well, that's really a downer. That means, you know, science has limitations, but it also means something else. It means that the passage of all of these applications of rules and so on, which we'll talk about as being corresponding to the passage of time, that passage of time, actually, in a sense, achieves something. It's not the case that we can kind of lead our lives for however many years and say we can. We say we don't need to lead our lives through all those years.

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We can already predict in advance the answer is going to be 42, so to speak. The computational irreducibility means that that sequence of steps has a definite meaning, it has an irreducible content, so to speak. So okay, so what is time? Time is this irreducible process of computation of sort of next states of the universe. So the universe has some particular configuration. And then this these rules will be applied to figure out what's the configuration of the universe going to be next, so to speak. if you had the idea that those rules would be mathematical rules that have computational reusability, you would just say, well, you know, yes, there are these rules being applied, but we don't really need to apply those rules. We can just work out a formula, jump ahead and say what the answer is. But what computational irreducibility implies is that actually, no, we really do have to follow those rules. We have to explicitly run. We have to explicitly apply these rules over and over again.

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And so this experience of time, this this notion of time, time is this sort of inexorable

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(02)- do a complex thing, you have to have complex rules to set it up. But it turns out that ||in the computational universe|| that's just not true. ?? It's kind of like you could take a kind of computation and use it as a kind of telescope to look into this computational universe. ?? And kind of the first thing you see is this phenomenon that even though your rules, your program, are very simple, the behavior that you get can be very complicated.

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Okay. How does this relate to time? !! Well, there's a very important phenomenon that results from this fact that even very simple rules lead to very complicated behavior. Well, even Maruška from 5A would figure that out if she thought hard… And finally, it's a phenomenon that I call computational irreducibility. So here's how it works. So in traditional science, especially in physics, one is used to the idea, oh, let's find the basic laws, the basic rules according to which a system works. For example, I have here ***The principle of alternating symmetries with asymmetries*** → https://www.hypothesis-of-universe.com/docs/eng/eng_008.jpg ; that's my idea, which I think is damn important and even that without it the genesis of anything is impossible…, Equations alternate with inequalities, https://www.hypothesis-of-universe.com/docs/eng/eng_009.pdf ; even !!!!, that, I think, is necessary in the model of the cyclic universe : the first cycle when alternating symmetries with asymmetries slowly and surely *rushes* into the big-cruich, and there all the curvatures of the 3+3 dimensions of space-time ***straighten*** and… and a flat infinite space-time occurs, without matter, (***even matter "unfolds" because is / was built from the dimensions of spacetime***), without the flow of time, without the expansion of the universe (space) and… and at 'this moment' suddenly that Big-Bang No. 2 occurs, which is an "instantaneous" change of the state of spacetime uncurved with **k=0** to the state with **k= inf**. In this cycle of Universe No. 2, the big-bang is the BIGGEST step of the "genesis", "alternating symmetries with asymmetries" from **k=0** to **k=inf.** And…and then again a new genesis of countless alternations of curvatures of dimensions and with that alternation of symmetries with asymmetries will run…up to cruich no. 3….then no. 4 …and no. “n”. And then we are kind of done, because somehow we imagine that as soon as we get these laws, from whom? From God or Beelzebub?

we can represent them mathematically. We can basically write a formula for what the system is going to do. So we can immediately say that this is what's going to happen in the system. We can predict what's going to happen in the system, where we can use our formula to see what the system is going to do. And that's much easier than the computational effort that the system has to put in to do what it's doing. What the system itself does may not be the same as what the system does after we apply "our" formula "to it." A typical example of this two-body problem. In celestial mechanics, you have an idealized sun, an idealized earth.

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And you have these equations that describe the motion of an idealized earth around an idealized sun. And those equations, we can just write a formula to solve these equations. This is an example where the probability of the system's behavior matching the system's behavior according to the formula is enormous. In more complex cases, it's not. So if you want to know where the earth will be in a million years, you don't have to watch a million orbits. O.K. But if you want to know when the mutation happens, that ape turns into a human, you have to "wait for the coincidence of act of nature and act of, scientist's formula". You can just say, I'll plug the number millions into my formula and I'll immediately get the answer that we've kind of hoped for in a lot of traditional sciences. We hope that these kinds of computational predictions reduce stability. Well, it turns out that there are a lot of systems in the computational universe that don't exhibit this kind of reducibility. I would say they exhibit computational irreducibility. They exhibit the phenomenon where you can, if you like, say what the system will do after a million applications of this rule? Well, you can run those million applications of the rule and see what the system does. But it turns out that this is some kind of irreducible computation. You can't find a way to jump ahead and say,

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I know what's going to happen. It's going to come up with the answer 34 or something. You just follow the steps to see what happens. And so that's a way of thinking about science. It's a significant thing because it kind of says that science has its limitations that arise somehow within science itself. Well, I wouldn't exactly call it that. There are things where you can't just say, we've got it. We know the answer right away. O.K. I just 'explained' it a little bit further up in the text (with the monkey). And, you know, I think one thing to understand about computational irreducibility is that you could say, well, that's really a damping. It means, you know, science has limitations, but it also means something else. It means that the passage of all these applications of rules and so on, which we'll talk about as corresponding to the flow time, the passage of time actually achieves something in a sense. The passage of time, (which is the unfolding of the time dimension) reaches a "future number on the time dimension" where "a change of state is made." The same goes for "positions in space"…, the system of unfolding space gets to a position where that change of "positional prediction" made by the universe, not made according to a human formula, occurs… It's not that we can lead our lives for however many years and say that we can. We're saying that we don't need to lead our lives for all those years.

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We can already predict in advance that the answer will be 42, so to speak. Computational irreducibility means that this sequence of steps has a certain meaning, has an irreducible content, so to speak. Okay, so what time is it? Time is this irreducible process of calculating some other states of the universe. So the universe has a certain specific configuration. And then these rules will be applied to find out what the configuration of the universe will be, so to speak. This is true in "simple systems" and by simple I mean those Kepler and Newton laws, if you had the idea that these rules would be mathematical rules that have computational reusability, you would just say, well, you know, yes, these rules apply, but we don't actually need to apply these rules. O.K. We can just work out a formula, jump ahead and say what the answer is. This is true in "simple systems". But what computational irreducibility implies is that we don't actually, we really have to follow these rules. We have to explicitly run. We have to explicitly apply these rules over and over.

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And so this experience of time, this idea of time, time is so relentless you probably mean "flow – the pace of time", or the movement of an object along the time dimension…

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(03)- application of rules to the things that are the structure of the universe. Now, one reason it's been sort of confusing and one hasn't been able to see that, is because traditional models of physics have tended to be based on mathematical equations, which have the feature that you kind of always hoping you're going to get this kind of computationally reducible solution. You're always kind of and there are even in the way equations are set up, like partial differential equations and so on, there really is very little distinction made between initial value equations where you say this is the initial condition and it's going to have to work out what happens after that. (*) And things like boundary value equations where you say, this is this is what happens at the sort of two ends of the application of this equation. And now we're going to fill in what's in the middle. In traditional mathematical formulations of physics, there isn't much distinction made between those things.

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When you think about physics as this thing, based on what one can think of as computational rules, there's a big distinction between those things. Because of computational irreducibility, we have these underlying rules. We can apply them step by step by step and see what happens. But we can't expect to jump ahead. We can't expect to say, oh, we know these two N's, let's fill in the middle. And so on. We have to just sort of follow the steps see what comes out. And so this, this phenomenon of time is the phenomenon of the sort of progressive computation of next states of the universe. And it's the fact that there is computational irreducibility that makes there be some kind of rigid structure to time, that makes there be something where time doesn't just crumble when you when you say, let's just figure out what's going to happen, you kind of have to live through those steps, lived through that, that time. Now there are many, many pieces of this. For example, one of the issues is

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if you look at different kinds of things, whether you look at experience of us humans, whether you look at sort of things happening in nature, there's this question of sort of is the way that time is running in those cases, is it is it the same or is it somehow time is different there are many pieces to this whole story, but sort of the, the first step is this idea that the progress of time is the inexorable progress of computation. Now, there are many pieces that we have to talk about. I mean, for example, one thing is, is that only one kind of time or other different kinds of times for different systems, it's kind of a little bit like what happened with temperature back in the day. People wondered, you know, that was temperature measured by the the expansion of mercury, that was temperature measured by, you know, change of electric resistance of this or that thing. And then it became realized that there was an absolute scale of temperature, that there was some there was some intrinsic thing

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which we later learned was the motion of molecules. That gave us kind of an absolute notion of temperature. Well, so it is with time. And the thing which is kind of the analog of that is computational irreducibility. The fact that there is the same phenomenon of computational irreducibility across all these different kinds of systems, and that there is the sort of the same ultimate kind of scale of application of computation across all these different kinds of systems that leads to some kind of absolute notion of time that isn't doesn't depend just on the particular system that your your kind of studying time with, so to speak. It doesn't depend on whether you're using a pendulum clock or some, you know, modern, you know, quantum, time measuring device or whatever. So it's so that's another piece to the story. I mean, the, there's a lot to say about kind of the relationship between time and space.

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There's, a lot to say about kind of, our experience of time. So things get let's see. I mean, the there are many different directions to go here, but, let's talk a little bit about time versus space and the in kind of one of the things that's been sort of one of my big excitements last 4 or 5 years has been these discoveries we've made in fundamental physics, which just with every passing month, every passing year, it's kind of like, yep, this is it. This is the story. And it's pretty neat. You know, it's the last really big kind of, paradigmatic change in physics was basically 100 years ago. And we've been sort of operating out of the same playbook for 100 years. And 100 years ago, people kind of suspected some of the things that we've now seen to be the case. So although they didn't have kind of the machinery to understand what was going on,

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I mean, I think probably a starting point for all of this is kind of we go back to, you know, ancient Greek times, people were discussing, you know, is the universe discrete or

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(03)- applying rules to things that are the structure of the universe. One of the reasons it was kind of confusing and one couldn't see it is that traditional models of physics tended to be based on mathematical equations, which have the property that you kind of keep hoping that you're going to get this kind of computationally reducible solution. You're always kind of, and even in the way the equations are set up, like partial differential equations and so on, there's really very little distinction between initial value equations, where you say this is the initial

condition, and you're going to have to figure out what happens next. And things like boundary value equations, where you say this is what happens at the two ends of the application of this equation. Be careful that in the Universe, equations always don't hold. I even dare to say that in the Universe, **ONLY inequalities** hold. Equations are just a "rare abstract artificial interface" between "running inequalities" to other "running inequalities". This means that I am talking about my ***Principle of alternating symmetries with asymmetries.*** https://www.hypothesis-of-universe.com/docs/eng/eng_008.jpg ; https://www.hypothesis-of-universe.com/docs/c/c_185.jpg ; https://www.hypothesis-of-universe.com/docs/c/c_221.jpg ; Entropy is a clear example of this: the system "gradually changes order into disorder", but...but suddenly there comes a "jump moment", when disorder "jumps" to a higher, more ordered level. (Otherwise, after the big bang, when, for example, the first protein was created, the state of genesis could not have produced living beings such as humans). Genesis in the Universe is also an example of this. For genesis, "quality times quantity is constant" applies. The more complex (more organized) a system is, the less and less it is quantitatively. Quality times quantity is constant https://www.hypothesis-of-universe.com/docs/eng/eng_009.pdf ; https://www.hypothesis-of-universe.com/docs/aa/aa_037.pdf ; (this is also my reason why I say that we are alone in the Universe. We are at the top of the pyramid, ||we are the most complex "thing" in the Universe||. If even one civilization were found, we could declare that there are plenty of them, an infinite number). And now we will fill in what is in the middle. In traditional mathematical formulations of physics, there is not much distinction between these things.
10:06
When you think of physics as this thing, based on what can be considered computational rules, there's a big difference between these things. Because of computational irreducibility, we have these basic rules. We can apply them step by step and see what happens. But we can't expect to jump forward. Where *forward* and what jumps We can't expect to say, oh, we know these two N's, fill in the middle. And so on. We just have to follow the steps to see what comes up. And so this, this phenomenon of time is a phenomenon of some kind of progressive **calculation** of other states of the universe. The universe is getting old, it's 13.8 billion years old now, and how do you want to ""calculate"" the state (complexity) of the universe over time?? How do you find out the age of the reaction sulfuric acid + base = salt??? You're saying that the "phenomenon of time = age" is there to calculate >states of the universe. That's either a white bluff, or you know that from experiments, right?
And it's a fact that there is a computational irreducibility that creates a kind of rigid structure of time, what is a "structure of time", I don't know?! that creates something where time doesn't collapse, what is a "collapse" of time, I don't know...?!
when you say, let's just figure out what happens, you have to experience those steps, experience that time. Sure, interactions happen in the flow of time, but "how" does the flow-flow of time affect the "performance of a specific interaction"? That (interval of time) should somehow be mathematically "fitted" into the interaction, right??? Nowhere in the physical-mathematical equations do you write how the flow-flow of time "co-creates" the result of the interaction. Now there are many, many pieces. One of the problems is, for example

11:04
when you look at different kinds of things, whether you look at our human experiences, whether you look at different things that happen in nature, there is this question, **in what way**

in these cases time runs, yes, that is the question: why is time (the passage of time) not included=counted into the interaction, into the course of the interaction as a "necessary artifact", whether it is the same, or is time somehow different, this whole story has many pieces, but somehow, the first step is the idea that the progression of the flow-flow of time is an inexorable progress of counting. O.K. that is what I am talking about here. Now there are many pieces that we have to talk about. I mean, for example, one thing is that there is only one kind of time what is it? or other different kinds of times ?? "kind" of time means "different rates of flow" ??? for different systems, it is a bit like what happened with temperature in the past. Heat=energy, temperature=state of chaos of dimensions=boiling of a system… (yes?) People wondered, you know, it was temperature measured by the expansion of mercury, it was temperature measured by, you know, the change in electrical resistance of this or that thing. And then he realized that there was an absolute measure of temperature, that there was some internal thing
12:05
which we later learned was the movement of molecules. Molecules=packages nested in boiling spacetime (yes?). That gave us an absolute idea of temperature. Well, so it is with time. And the thing that is kind of analogous to that is computational irreducibility. The fact that in all these different kinds of systems there is the same phenomenon of computational irreducibility and that in all these different kinds of systems there is some kind of finite kind of use of computation that leads to some absolute idea of the rate of time time that is not, does not depend only on the particular system that you are studying with, so to speak. It does not matter whether you are using a pendulum clock or some, or here you are just emphasizing "that rate of flow" by various mechanisms... you know, modern, you know, quantum, devices for measuring the rate of flow of time or whatever. And how-how does the rate of flow of time affect your interaction?? So that's right, that's another part of the story. I mean, there is a lot to say about the relationship between time and space. ?? I thought you were describing the "relationship between time and interactions".
13:04
There's a lot to say about our kind of experience of time. So we'll see. I mean, there's a lot of different directions we can go here, but let's talk a little bit about time versus space and one of the things that's been kind of one of my big excitements over the last 4 or 5 years has been these discoveries that we've made in fundamental physics, which with every passing month, every passing year, it's kind of like, yeah, this is it. That's talk like from a nutcase... This is a story. A story of a nutcase, a nutcase... And it's pretty neat. You know, it's it the last really big kind of paradigmatic change in physics basically 100 years ago. What kind of paradigmatic change is it? What? I haven't gotten the point yet=I haven't read the text - How about doing a "paradigmatic change" with the gravitational constant? (see my visions and reflections in other articles. 100 years of a dragging paradigm). And we've kind of been operating by the same playbook for 100 years. And 100 years ago people kind of suspected some of the things that we've seen now were the case. So even though they didn't have the machines to understand what was going on,
14:01
I think, I think probably the starting point of **all of this**, **what??, is that we go back to ancient Greek times, people were debating, you know, is the universe discrete or continuous?. And that's the 100-year-long paradigm??

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(04)- continuous? Are there atoms or does everything the universe kind of flow like water? Well, it took a really long time to resolve that question. It wasn't until the end of the 19th century that it became clear that, yes, molecules exist. We were lucky enough that the scale of our microscopes and so on, relative to the scale of molecules was such that we could actually see Brownian motion happening and we could tell, yes, there really are discrete molecules. Then we found out they're also discrete photons of light and so on. And actually in the in the first few decades of the 20th century, most physicists believed that space was discrete as well. I hadn't really realized this until recently. I've been finding all of this stuff, which was never really published, because they never managed to make a model like that work. Einstein, Bohr, Heisenberg, they all thought that space was discrete. And as they tried to make models where that would happen,

15:06

they couldn't make those models consistent with relativity. There was ended up with things where they put down some some rigid lattice in space, for example, and then they say, well, you know, but we know that relativity says it doesn't matter what, what frame, you know, what how we're traveling relative to this lattice, taking time to make that work. So 100 years later, we can make that work, partly because we have this much more computational kind of infrastructure to think about what we build space and everything in the universe out of, and kind of the, underlying idea of what what we've done is to think about space, the universe, everything in space as being represented by this giant network. And so what are the things in this network, the things in this network of what we can think of as atoms of space, these kind of point objects whose only feature is that they're distinct from each other.

16:03

these atoms of space are related by this network that says this atom of space is related to these other atoms of space. That's kind of the the whole that's kind of the data structure of the universe. And the really surprising thing, I mean, the first really surprising thing is you say, well, okay, if you have zillions of these atoms of space and you have this network and it's being continuously rewritten as pieces of it, follow these rules and change into other pieces of network. What does that look like when you've got ten to the 100 atoms of space? What is the aggregate behavior of such a system? Well, there's an analogous problem. When you think about a fluid, for example, you've got all these molecules bouncing around and you ask, what's the aggregate behavior of all the molecules in a fluid. And we know well that's fluid mechanics. It's the equations of fluid mechanics and area Stokes equations and so on. So the question is what's the analogous limit of this graph being rewritten and so on.

17:02

But turns out the analogous limit is the Einstein equations. So the equations of space time that you're very familiar with that's kind of the first big clue that something interesting is happening is you kind of inexorably dealing with the fact that from that microscopic structure of just atoms of space and rewrites and graphs and so on, you end up getting the Einstein equations. And, you know, we can see a lot of detail, actually, we have decent simulations of things like black hole mergers. Black holes are very convenient because a really tiny black hole

that is just a small number of sort of, atoms of space across, so to speak, a really tiny black hole behaves in the same way as a big observable black hole. And so we can kind of do something where we're kind of just simulating these really tiny black holes, and we can see

them merge and produce gravitational radiation and all sorts of good things like that. that's kind of a notion of, of what space is there then questions about, about relativity and,
18:07
how relativistic invariance occurs, things like that. This is a slightly, slightly deeper rabbit hole. But the key idea is you've got this notion of space. Space is this hypergraph that's laid out with all these atoms of space time is the inexorable rewriting of that hypergraph by these computational rules. But the thing to understand is, what does an observer like us observe what's going on in the system, remembering that an observer like us must be embedded within the system. We are part of that system, and the thing we realize is that all that we can observe is the causal relationships between these updating events. So one way to think about it is imagine that
19:01
we were not being updated. Then whatever's happening in the universe, we're not going to know what happened. We're only going to know what happened when we've also been updated. So in a sense, what what ends up being the case is that all we can really be sensitive to is this network of of the relationships, the causal relationships between updating events. So

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(04)- continuous? Are there atoms or everything in the universe flows like water? So interactions also "flow"... Interactions written on paper do not flow!!!! Tell me what is the **difference** between the flow of an interaction on paper and in reality? It took a really long time to solve this question. !! So tell me. It was only at the end of the 19th century that it turned out that yes, molecules exist. O.K. and so "how do they flow"?? We were lucky that the scale of our microscopes and so on, relative to the scale of molecules, was such that we actually saw Brownian motion and could say, yes, there really are discrete molecules. O.K. Then we found out that they are also discrete photons of light and so on. Discrete = package = ball of dimensions. And in fact, in the first few decades of the 20th century, most physicists believed that space was also discrete. O.K. On the length dimensions, "knots" are created => for packages of elementary particles. https://www.hypothesis-of-universe.com/docs/c/c_411.jpg ; https://www.hypothesis-of-universe.com/docs/c/c_421.gif ; https://www.hypothesis-of-universe.com/docs/c/c_426.jpg ; https://www.hypothesis-of-universe.com/docs/c/c_422.gif ; https://www.hypothesis-of-universe.com/docs/c/c_461.jpg several dimensions (with knots) come together to form a quark, then an elementary particle, then an atom, molecules, etc., etc. I didn't really realize this until recently. I found all this stuff that was never published because they never managed to create a model that worked. **Einstein, Bohr, Heisenberg**, they all thought that space was discrete. https://www.hypothesis-of-universe.com/docs/c/c_461.jpg And when they tried to create models where this would happen,
15:06
they couldn't make those models consistent with relativity. How simple Sherlock… It ended up with things where, for example, they put some rigid grid in space, and then they said, well, you know, but we know that relativity says that it doesn't matter what, in what frame, you know, how we move relative to that grid, https://www.hypothesis-of-universe.com/docs/c/c_425.jpg and it takes time for that to work. So 100 years later we can do that, partly because we have a much more computational kind of infrastructure to think about what we're building the universe out of (only two-dimensional quantities, so matter) and

everything in the universe, and so the basic idea of what we've done is think of the universe, the universe, **everything** in the universe as represented by this giant 3+3D grid !!. And so what are **things** in this network, dimensions of things in this network of what we can think of as atoms of space, https://www.hypothesis-of-universe.com/docs/c/c_461.jpg ; these kinds of point objects whose only property is that they are different from each other.
16:03
these atoms of space, packages, balls of dimensions (real quantities) are connected by this network, which says that this atom of space is related to these other atoms of space. This is something like a whole, which is a kind of data structure of the universe. And the really surprising thing, I mean, the first really surprising thing is that you say, okay, okay, if you have millions of these atoms of space and you have this network and it's constantly rewriting itself to parts of it, follow these rules and change to other parts of the network. What does it look like if you have ten to 100 atoms of space? What is the aggregate behavior of such a system? Well, there's a similar problem. For example, when you think about a fluid, all these molecules are bouncing around, and you ask what is the aggregate behavior of all the molecules in the fluid. And we know well that's fluid mechanics. They're the equations of fluid mechanics and the surface Stokes equations and so on. So the question is, what is the analogous limit of rewriting this graph and so on.
17:02
But it turns out that the analog limit is Einstein's equations. So spacetime equations, I don't know the spacetime equations. Do you? Show them, which you know well, is kind of the first big clue that something interesting is going on, is that you're kind of inexorably dealing with the fact that from that microscopic structure just **atoms of space** *and transcripts and graphs* and so on **you get** Einstein's equations. ?? Who's crazy here, you or me? And, you know, we can see a lot of detail, actually we have decent simulations of things like merging black holes. Black holes are very convenient because they're really small black holes, it's just a small number of atoms of space across, so to speak, a really small black hole behaves the same way as a big observable black hole. And so we can do something where we kind of just simulate these really small black holes and we can see them merge and produce gravitational radiation, ? and all sorts of good stuff. That's kind of the idea the idea is just a hypothesis... about what kind of space is there, and then questions about relativity and,
18:07
how relativistic invariance happens and stuff like that. This is a little, little bit deeper rabbit hole. But the key idea is that you have this idea of space. O.K. Space is this hypergraph that is laid out with all these spacetime atoms, is an inexorable rewrite of this hypergraph by these computational rules. But you have to understand what an observer like us, observes, what's going on in the system, when we remember that an observer like us has to be part of the system. We're part of this system and we realize that all we can observe are causal relationships ?? we don't observe anymore?? between these update events. So one way to think about it is to imagine that
19:01
we haven't been updated. Whatever happens in the universe, we won't know what happened. We won't know what happened until we're updated too. So in a sense, the only thing we can be sensitive to is this >web of relationships, the causal relationships between update events<. So be it… So

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(05)- for example, let's say you have this little update that happens and it produces certain output. Well then you can ask well what other update events depend on the output from that first update event. And from that you can build up this causal graph of what what affects what. And it's that causal graph that is the real sort of substance of what's going on in these models. And that causal graph is, in a sense, a graph that connects both space and time. These events, one can think of them as in the end, we will perceive them as being as occurring at certain places in space and time.
20:01
And what's happening in this, this graph, the graph is the only sort of reality to the system. And the question is then how do we pass that graph as observers and what ends up happening? So key fact about us as observers that many things about what goes on that depend on our nature as observers. So one thing about us as observers, that's not obvious, is that we can pass the universe as consisting of states of space at successive moments of time. When you say thing or you mean to measure the. You know, we can make, observational measure. we understand the universe to consist of. There's this state of space at this moment in time. Then there's another state of space at a separate at the subsequent moment of time. So in our everyday experience, that's what happens. You know, if you look around the room, you know, maybe, you know, you see something that's ten meters away.
21:00
Well, the light from something ten meters away gets to your eye in a microsecond. but your brain takes milliseconds to process that signal. And so to you, all the photons arrive simultaneously from that, from all the photons from your local environment arrive as far as you're concerned, in a blink of an eye, so to speak. In the time it takes neurons to respond. So for your brain, it's as if the there is a state of space at a certain moment in time. And then there's another state of space at a subsequent moment of time. Now, you know, in your day job, so to speak, you're dealing with things that aren't ten meters away. You're dealing with things that are, you know, ten to the 25m away or something, ten to the 26m away. And when in, in that case, this kind of idea that we have that there's sort of space separate from time and we can just think of an instantaneous state of space doesn't work anymore. It wouldn't work for us
22:03
if our brains worked a million times faster than they do. And we were still, you know, living in rooms the same size as we live in now. then we would be a brain like a piece of digital electronics that can see the photons. It will see the individual photons. And the fact that we will decide to think of space as being this, you know, the state of space at successive moments of time. That's that's a feature of the particular scale we're at and the particular characteristics we have as observers. It's not, in a sense, the intrinsic nature of what's going on. And so, for example, in these models, what's more intrinsic is this causal graph of little tiny updating events that are happening all over the universe. That's the thing where we have to pass that graph. We have to we have to say we're going to we're going to choose to slice that graph so that we have these states of space at successive moments of time. the jargon of relativity, that will be space like hyper
23:03
surfaces. We are defining simultaneity surfaces. So what we can say is if we've got these updating events, one update event follows from another follows from another. Those we can say a time like separated events. One event affects another event at a later time. But then the

big thing that's sort of a big story of relativity is this idea that different events may not be timelike separated. The thing that's happening on Mars and the thing that's happening on Earth are not they can happen at the same time. We can. We have to define what this what the surface of simultaneity looks like. In other words, we say, you know, it's noon on Earth. When is it noon on Mars? Is it noon on Mars? You know, when a light signal from Earth, from the, you know, the noon light signal from Earth reaches Mars? Or is it noon on Mars at a different time? And so we end up with this kind of a space like hyper surface, this simultaneity surface where we.

24:03

Well. And what what's happening in this causal graph story is we're simply taking the slice of the causal graph. And we're saying these events we consider to be simultaneous and time. And there is a consistent say that we can we want events to be in these successive slices, representing events that are sort of at successive moments of time. And there's a consistency that we have to have that those events in successive space, like hyper surfaces, can never be time like connected to each other. that has to be the case that within one simultaneity surface,

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(05)- let's say for example you have this little update that happens and produces a certain output. Then you can ask what other update events depend on the output of this first update event. And from that you can build this causal graph of what what affects what. And it's the causal graph that's the real essence of what's going on in these models. Okay... And that causal graph is in a sense a graph that connects space and time. Einstein already did that...(maybe in another graph). These events, you can think of them as at the end, we'll perceive them as happening at certain places in space and time. O.K. this still doesn't say anything...

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And what's happening in this, this graph, the graph is the only kind of reality system. And the question then is how do we pass that graph on as observers and what happens in the end? So the key fact about us as observers is that a lot of things about what happens depend on our nature as observers. So one thing about us as observers that is not obvious is that we can go through the universe as being composed of states of space at successive instants of time. When you say something or you want to measure something. You know, we can make an observational measurement. We understand that the universe is composed. At this instant there is this state of time and space. Then there is another state of space and time in separate at the next instant of time. So in our everyday experience this happens. You know, when you look around the room, you know, maybe, you know, you see something that is ten meters away. and… 0.3335 $.10^{-7}$ seconds old.

21:00

Well, light from something ten meters away takes microseconds to reach your eye, 1 microsecond (symbol µs) is a millionth of a second, 1 s = 1,000,000 µs. 1 millisecond = 0.001 seconds = a thousandth of a second, → 0.3335 $.10^{-7}$ seconds, but it takes your brain milliseconds to process that signal,

0.3335 $.10^{-4}$ seconds. And so all the photons arrive at you at the same time, of all the photons from your local environment arrive, as far as you're concerned, in the blink of an eye. In the time that the neurons respond. So for your brain, it's like there's a state of space at a certain point in time. And then there's another state of space at the next point in time. Now, you know, in your daily work, so to speak, you're dealing with things that aren't ten meters away. You're dealing with things that are, you know, ten to 25 meters away or something like that, ten to 26 meters away. And when we're in this case, this kind of idea that there's some space separate from time and we can just think about the instantaneous state of space doesn't work anymore. ?? It wouldn't work for us

22:03

if our brains worked a million times faster than they do. ? And we still, you know, lived in rooms the same size as we live in now. Then the brain would be a piece of digital electronics that sees photons. It would see individual photons. And the fact that we choose to think of space as this, you know, the state of space at successive moments in time. Well, sure. But I'm still waiting to see what comes out of that, what purpose it's being said here... That's a feature of the particular scale, ($c = 2.9979246 \,.\, 10^8 / 10^0$) that we're at, and the particular properties that we have as observers. In a sense that's not the intrinsic nature of what's going on. And so, for example, in these models, what's more intrinsic is this causal graph of little tiny update events that are happening all over the universe. And what comes out of that? What insight? That's the thing where we have to pass on that graph. To whom? Why? We have to say that we are going to decide to partition the graph so that we have these states of space at successive moments in time. In relativity jargon, that would be space as hyper

23:03

surfaces. We define simultaneity surfaces.? So we can say that if we have these update events, one update event follows another follows another. And in the forest, each tree follows each tree… We can say that time as separate events. Forest as separate trees… One event will affect another one event at a later time. The first atrom in the first forest will affect the second tree in the same (different) forest… But the big thing, which is in a way the big story of relativity, is the idea that different events do not have to be separated in time. A thing that happens on Mars and a thing that happens on Earth ~~cannot~~ need to happen at the same time, for an observer on Jupiter… We can. We have to define what the simultaneity surface looks like. In other words, we say, you know, it's noon on Earth. When is it noon on Mars? Is it noon on Mars? You know, when the light signal from Earth, you know, the noon light signal from Earth reaches Mars? Or is it noon on Mars at some other time? The question is whether there is a "uniform rate of flow" of time in the universe. And we don't know. But we can judge (infer) that uniform time doesn't flow everywhere. Because of gravity, that is, because of the uneven motion in different gravitational fields, which is in other words, different curvatures of the space-time of the observed location… And so we end up with this kind of space, like a hypersurface, this simultaneous surface where we are.

24:03

Okay. And what happens in this story about the causal graph is that we just take a part of the causal graph. And we say that we consider these events to be simultaneous ?? and temporal. And there is a consistent statement that we can want events to be in these consecutive slices, which represent events that are somehow in consecutive moments in time. And we have to have the consistency that these events in consecutive space, like hypersurfaces, can never be temporally connected. I can't judge that without deeper thought ◊ (laziness wins). It must be the case that within one simultaneous surface,

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(06)- those events another time like related to each other. They they have to be They're not accessible.

The role of computational irreducibility in thermodynamics

You cannot access them in. All right. You. You mentioned in the. Towards the end of the essay, time remains that computational process by which successive states of the world are produced. Then you say computational irreducibility gives time, a certain rigid character, at least for computationally bounded observers like us.

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That gave me chills, Stephen, because it suggests that maybe there aren't bounded computationally, at least observers. What would those observers be like? one of the biggest things that's emerged in my kind of thinking about sort of, the universe and everything in the last couple of years has been the fact that the reason we observe the laws of physics we do is because we are observers of the kind we are. I never imagined that it would be possible to derive the laws of physics. I always assumed that the laws of physics were just like, well, we've got this universe, Right. The instruction manual aren't. they would be derivable. The first kind of clue that they might be is the second law of thermodynamics. So the second law of thermodynamics, which was first talked about in the in the mid 1800s, is this thing that says where you got all these molecules, for example, in a gas, they're bouncing around the colliding with each other. According to the laws of mechanics, which we know.

26:00

But yet in the aggregate, gases tend to get more random in the configurations of molecules. And we can say things like that, entropy increases. And kind of seems like it was very tantalizing in the 19th century, particularly very tantalizing trivia fact, actually, in the invention of so in 1905, you know, Einstein wrote three very famous papers relativity, the photoelectric effect, Brownian motion. In 1904, he wrote a couple of papers, and they were supposed proofs of the second law of thermodynamics, and they were wrong. And so. And I don't think Einstein ever returned to the second law of thermodynamics. But what was really interesting to me in terms of history of science, those papers were really a follow on to the work of Boltzmann, who was sort of the person who really pioneered kind of the atomic theory of gases and things like this, and kind of had the idea that matter is made of discrete atoms and that you could build physics and theory of heat and so on from that. but it's sort of interesting that Einstein had a similar kind of

27:05

you can derive this notion in 1904 for the second law of thermodynamics. It didn't work in the case of relativity in 1905, it did work. And same kind of methodological idea. Well, the thing that's really a surprise now is it looks like we really can derive these laws of physics. So the second law of thermodynamics, what really is it? It's actually a story of computational irreducibility. Because here's what happens. You start off with these molecules. Let's say they're all in one corner of a box. They're a very orderly configuration. Then you let them collide and follow the laws of mechanics. What they are doing is performing a computation. It's an irreducible computation. So what comes out of that is something which no longer has a trace of what happened at the beginning of the fact that these molecules were all in a very organized state, because that initial condition

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has been essentially encrypted by the progress of computation in the system, it's been encrypted by this irreducible computation. Okay. So then we come along and we look at the results of that computation and we say looks kind of random to us because we can't invert that

irreducible computation because we with our brains, with our measuring devices, we are computationally bounded observers. We can only do a limited amount of computation. And so when that's compared to the irreducible computation that the gas has done, we come up short and we just say looks random to us. And that's basically the second law of thermodynamics. And so in other words, the second law of thermodynamics is a consequence of the fact that there is underlying computational irreducibility sort of interacting with us as computationally bounded observers. if you go down to the scale of individual molecules and you can do a little bit of computation about what's going on, then in a gas with only 20 molecules in it
29:03
or something, you can break the second law of thermodynamics, because you can break computational irreducibility, because with a sensitive enough measuring device that can look at individual molecules and with good simulation and so on, you can say, I know what's going to happen. I know happened before. So that's a case where the computational capability of the observer is strong enough relative to the system that you break the second law of

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(06)- those events that are sometimes related. They must be. They are not accessible. ?? **The role of computational irreducibility in thermodynamics**. You cannot access them. Okay. You. You mentioned in. Towards the end of the essay, time is the computational process, time is not a process…, time is the pace of cutting intervals into time dience. That pace cannot be determined until we have a "fixed point", so time is and will be a "co-creator of changes", a co-producer of changes in matter and curvatures of space-time. Time is not just a "medium" in which the processes of changes in >matter and space< run, time co-creates the transformation of matter, time is built into matter...((note: a...and that's why I think that physicists will not succeed in fusion at CERN and elsewhere, because they have not yet explored "how and why" time is built into matter = the time dimension in my "formulas" for light elementary particles of matter https://www.hypothesis-of-universe.com/index.php?nav=eb , by which successive states of the world are created. Successive state of nuclear fusion at CERN...; I think that fusion has something to do with Heisenberg = the uncertainty principle. https://www.hypothesis-of-universe.com/docs/h/h_054.pdf ; https://www.hypothesis-of-universe.com/docs/f/f_043.jpg ;

$m \,.\, v \,.\, x_c = \quad m_0 \,.\, c^2 \,.\, t_c \,.\, \mathbf{t_c / t_v}$;

$\Delta p \,.\, \Delta x = \Delta E_0{*} \,.\, \Delta t \quad = \quad \Delta E_0 \,.\, \Delta t \,.\, \mathbf{t_c / t_v}$ …… Heisenberg corrected

https://www.hypothesis-of-universe.com/docs/f/f_039.pdf Then you say that computational irreducibility gives time, at least for computationally limited observers like us.
25:03
That gave me chills, Stephen, because it suggests that maybe they're not computationally limited, at least observers. What would those observers be like? One of the biggest things that's come up in my way of thinking about the universe and everything over the last few years has been the fact that the reason we follow the laws of physics is because we're the kind of observers we are. I'm not entirely sure where he's going with this and what he's trying to say... I never imagined that it would be possible to deduce the laws of physics. Why don't you give an example? I always assumed that the laws of physics were like, well, we have this universe, right. There's no instruction manual. They would be deducible. The first kind of clue that they could be is the second law of thermodynamics. So the second law of thermodynamics, which was first discussed in the mid-19th century, is this thing that says,

where did you get all these molecules, for example, in a gas, bouncing around each other. According to the laws of mechanics that we know.
26:00
But in general, gases tend to be more random in the configurations of the molecules. And we can say things like, entropy increases. https://www.hypothesis-of-universe.com/docs/aa/aa_454.pdf ; https://www.hypothesis-of-universe.com/docs/aa/aa_439.pdf here p. 21; https://www.hypothesis-of-universe.com/docs/aa/aa_360.pdf ; https://www.hypothesis-of-universe.com/docs/aa/aa_439.pdf ; And it kind of seems like it was very irritating in the 19th century, especially a very irritating trivial fact, in fact, at the time of his invention in 1905, you know, Einstein wrote three very famous papers on **a)** relativity, **b)** the photoelectric effect, **c)** Brownian motion. He wrote a couple of papers in 1904 and they were supposed to be proofs of the second law of thermodynamics and they were wrong. And so on. And I don't think Einstein ever went back to the second law of thermodynamics. But what really interested me from a history of science perspective was that those papers actually followed up on the work of **Boltzmann**, who was a guy who really pioneered a kind of atomic theory of gases and things like that and had this kind of idea that matter was made up of discrete atoms and that you could build physics and the theory of heat and so on from that. But it's interesting that Einstein had a similar kind of
27:05
you can derive this concept in 1904 for the second law of thermodynamics. In the case of relativity, it didn't work in 1905, but it did. And the same kind of methodological idea. Well, the thing that's really surprising now is that it seems like we can actually derive these laws of physics. So the second law of thermodynamics, what is it? It's actually a story about computational irreducibility. Because here's what happens. You start with these molecules. Let's say they're all in one corner of a box. They have a very ordered configuration. Then you make them collide and you follow the laws of mechanics. What they do is do calculations. It's an irreducible calculation. So what comes out of this is something that no longer has a trace of what happened at the beginning of the fact that all these molecules were in a very organized state, because this initial state
28:03
was basically encrypted by the process of computation in the system, it was encrypted by this irreducible computation. Okay. So then we come and look at the results of that computation and we say that it seems a little bit random to us, because we can't reverse that irreducible computation, because we, with our brains, with our measuring devices, are computationally limited observers. We can only do a limited amount of computation. And so when we compare that to the irreducible computation that the gas did, we come up short and just say that it seems random to us. And that's basically the second law of thermodynamics. And so in other words, the second law of thermodynamics is a consequence of the fact that there is a fundamental computational irreducibility of how it interacts with us as computationally limited observers. If you go down to the scale of individual molecules and you can do a little bit of computation on what's going on, then in a gas with just 20 molecules
29:03
or something like that, you can violate the second law of thermodynamics because you canbreak the computational irreducibility, because with a sensitive enough measuring device that can look at individual molecules and with a good simulation and so on, you can say, I

know what's going to happen. I know it's happened before. So that's a case where the computational power of the observer relative to the system is strong enough that you can violate the second law

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(07)- thermodynamics. but for an actual typical gas with all the, you know, billion, billion, billion molecules that might be in a little small region of gas, then the kind of computational capabilities of us as observers or our measuring devices is no match for that. So we just say for us, we observe the second law of thermodynamics. If we were observers who are not computationally bounded, we would not believe in the second law of thermodynamics. So that could be used to detect, you know, whether or not something is

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a computer a computationally limited or, you know, observer, just like a bounded observer like us.

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to some extent, yeah. So so here's a fun thing. Back in the 1860s when people were first talking about the second law of thermodynamics, one thing that people said is, oh, the universe will sort of have a miserable end in the heat death of the universe. What they meant was just like, you know, you start off with all sorts of mechanical motion and things are very organized, and eventually there's friction and heat is generated, and eventually everything kind of runs down to just be a whole bunch of heat. What is heat? Heat is this supposedly random motion of molecules. So people were saying, that's a terrible situation. You know, the trillion is in the future or something. There won't be anything in the universe other than random heat. That's a really bad end. But that end depends on what kind of observer is observing what happens. Because a computationally bounded observer to that computationally bounded observer. Yes, all those molecules bouncing around just seem completely random.

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But to an observer that's more computationally sophisticated, they're capable of seeing actually that configuration of molecules. That's the trillion year future of, you know, Brian and Stephen having that conversation, so to speak. And there are details there that can be seen by a computationally unbounded observer. But to us, as we are right now, as observers of the kind we are right now, it would look as if there's a heat death of the universe. Everything is just turned into random heat. But if we were not computationally bounded observers, we wouldn't think that we would say, oh, look at all these amazing molecules which have this complicated motion that comes from this very meaningful thing that happened 2 trillion years ago. so that's kind of how how that works. Now, the thing that's really remarkable to me is that both general relativity and quantum mechanics turn out, it seems to be derivable in the same way. So general relativity ends up being the interplay between computational irreducibility of all of these underlying processes

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and all these hypergraph through writings and so on. And the fact that we as observers of that are computationally bounded. So space at the smallest scale consists of all this complicated stuff going on. But to us, at the scale we're at, space just seems continuous. It seems like we can move from one place in space to another, and that's a feature of the fact that we are we are computationally bounded observers of that. if we were able to just detect exactly what's going on, we wouldn't believe in simple continuous space. So I'll give a couple of examples of that.

So for example the possibility of motion is non-trivial. So the fact that you can take a thing and move it in space and it's still the same thing is not obvious even in traditional general relativity. You know, if you're right next to a space time singularity, you can end up that your thing, your spacecraft, whatever else it is, can't just move there because kind of space is torn apart
33:06
at that point. And there can't be sort of a coherent spacecraft that. Right. And moving into space means that you're moving in time, right? The time and space actually get in inverted, right inside the. even different issue. But, but but the thing is, the possibility of pure motion is not a trivial thing. And it's a consequence of essentially computational boundedness that we end up believing in pure motion, for example, the fact that, you know, black holes, we think of those as just being characterized by what's outside the black hole. And we're not we're not kind of looking at all of the details of what's, you know, the the crinkling of the event horizon and so on. We just say it looks to observers like us, it looks like it's just a black hole. Even though there might have been a whole civilization crushed inside, the black hole just looks like a black hole. It's the same with electrons. We think that from the outside, so to speak, all electrons look the same. That's always been kind of mysterious. I think that in the end, the story will end up
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being electrons will end up being very much like black holes, and it will turn out to be the

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(07)- thermodynamics. But for a real typical gas with all these billions, billions, billions of molecules that could be in a tiny little region of gas, the kind of computational power of us as observers or our measuring devices is no match for that. So for us, we say that we obey the second law of thermodynamics. If we were observers who were not computationally limited, we wouldn't believe the second law of thermodynamics. So that could be used to detect, you know, whether or not something is **Ruliada and the nature of observers**, the computer is computationally limited or, you know, an observer, just as limited an observer as we are.
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to some extent, yes. So here's the funny thing. In the 1860s, when people first talked about the second law of thermodynamics, one thing that people said was, oh, the universe is going to have a kind of unfortunate end with the heat death of the universe. Heat is energy and energy is matter and motion and matter itself is a "packed conglomerate of dimensions of quantities" n. Since the big bang, dimensions have been unpacked both in space-time and in matter and...and one day it will really end with that thermal death, which will be the "unpacking" of all the packed dimensions... and in that matter. So far, only space-time is unpacking. Locally, space-time is being packed, which creates matter, which has been growing and increasing since the big bang. Today??, I don't know, but I think that there is/is already a kind of "balance" between the collapsing and unfolding of dimensions "in matter"..., but gradually we will return to extinction by unfolding all dimensions. Then comes the big-bang number 2. and the cycle repeats, then BB number 3, etc. see R. Penrose. What they meant was, you know, you start with all sorts of mechanical motion and things are very organized, and eventually there's friction and heat, and eventually everything just sort of comes together to be this whole bunch of heat. What is heat? Heat is this supposedly random movement of molecules. So people said, this is a terrible situation. You know, a trillion years into the future or something.

There's nothing in the universe but random heat. That's a really bad ending. But that ending depends on what kind of observer is watching what's going on. Because a computationally limited observer to that computationally limited observer. Yeah, all these molecules bouncing around just look completely random.
31:01
But to an observer who's computationally more sophisticated, they're able to actually see this configuration of molecules. That's a trillion years into the future, you know, Brian and Stephen are having this conversation, so to speak. And there's details that a computationally unlimited observer can see. But to us, as we are right now, as observers of the kind that we are right now, it would look like the heat death of the universe. Everything just turns into random heat. But if we weren't computationally limited observers, it wouldn't occur to us to say, oh, look at all these amazing molecules that have this complicated motion that comes from this very meaningful thing that happened 2 trillion years ago. So that's kind of how it works. What's really remarkable to me is that both general relativity and quantum mechanics seem to be derivable in the same way. I'm one ear... So general relativity ends up being an interplay between the computational irreducibility of all these fundamental processes
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and all these hypergraphs through writings and so on. And the fact that we as observers of it are computationally limited. So space at the smallest scale is made up of all these complicated things that are happening. But to us, at the scale that we are at, space appears to be continuous, smooth. It seems that we can move from one place in space to another, and that is a feature of being computationally limited observers. If we were able to detect exactly what is happening, we would not believe in a simple continuous space. So I will give a couple of examples. So for example the possibility of movement is non-trivial .That needs explanation!! So the fact that you can take a thing and move it around in space and it is still the same is not obvious even in the traditional general theory of relativity. You know, if you're right at a singularity of spacetime, you can end up with your thing, your spaceship, whatever it is, not being able to just move there because the kind of space is torn apart Spacetime can only be torn apart in the microcosm on Planck scales. In the macrocosm, spacetime is continuous and almost unwrapped. And in the middle of these extreme positions, (the position for OTR and the position for QM) spacetime and the matter in it, are "quantized" and "floating" in the basic totally flat lattice, the fabric of spacetime flat, uncurved, smooth. 33:06
at that point. And there can't be such a coherent spaceship. Right. Okay. And moving into space means you're moving in time, right? Time and space actually get reversed, right in.?? Even another problem. But, but the thing is, the possibility of pure motion is not a trivial thing. And it's a consequence of essentially computational limitations that we end up believing in pure motion, for example, the fact that, you know, black holes, we think of those as just being characterized by what's outside the black hole. And we're not, we're not looking at all the details of what is, you know, the wrinkling of the event horizon and so on. We're just saying that it looks to an observer like us, it looks like it's just a black hole. Even though an entire civilization could have been crushed inside, a black hole just looks like a black hole. It's the same with electrons. We think that from the outside, so to speak,
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all electrons look the same. That's always been kind of puzzling. I think the story ends up being that electrons end up being very similar to black holes, and it turns out that they are

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(08)- case that from sort of outside the electron. And when we look at it as observers like us, the electron just seems to be able to move without change. like an eddy in a fluid. You have this little swirl. And in water, for example, that swirl can kind of move through the water, but as it moves, it's it's using different molecules in the water to make itself. And it's the same thing with an electron or a black hole. It's using different atoms of space to make itself as it moves. By the way, there's a there's a kind of interesting consequence to this, which is something that comes up in relativity, which is if you think about kind of it's moving in space and it is essentially as it moves, it has to reconstruct its structure at a different place in space. And that process takes some kind of computational work,

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the actual process of the kind of progression through time of the thing. Let's say the thing is some kind of clock, that progression through time is using computational steps to make the text of the clock. And so what happens is if the thing is moving, then the the motion takes some amount of computation to achieve. Reconstructing the thing at a different place in space takes a certain amount of computation to achieve. So if the thing has a limited amount of computation, a fixed amount of computation, it has a trade off between using its computation to sort of evolve for itself through time, and using its computation to reconstruct itself, the different places in space. And so if you're moving faster in space, you are progressing, you are evolving more slowly in time. And that that's basically the story of time dilation.

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I mean, the, the, the data, which is really cool that that's sort of a mechanical explanation of time dilation. Now it gets, you know, the full story there in because you're really dealing with these causal graphs, not with just sort of a fixed structure of space. that's how you end up getting into, sort of traditional sense invariance and things like this. I mean, it's, it's a, I think, you know, the thing just to sort of finish this thought of, of this really remarkable fact, as far as I'm concerned, that the kind of what we perceive in the universe is really just a consequence of the fact that there's computational irreducibility underneath. And we are observers who are computationally bounded. And actually there's one more characteristic that we have to have to get general relativity and quantum mechanics, which is we have to believe that we're persistent in time, even though at every moment in time we're made of different

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atoms of space. You and I both believe that it's the same us now as it was a second ago. that's a way that we and in a sense, pass the universe by that assumption that it's the same us at successive moments in time. Persistence of memory. Right. that the fact that we treat it as being the same us. We don't say it's a and that's very important. And well, both in general relativity and in quantum mechanics and quantum mechanics, key thing that happens in this relates again to time in this rewriting, this hypergraph and all these kinds of things. It turns out there are many different ways that rewriting can happen. And each different set of rewrites essentially defines a different thread of history, a different sort of thread of time. Each each one of those different sequences of rewriting corresponds to a different history for the universe. And the thing that is non-trivial is because we believe

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we are persistent in time, and we believe we have the single thread of experience and time. We have to conflate all those different threads of history into a single kind of into the single thread of experience that we have. deeply analogous to what happens in both in terms of dynamics and in space time, that we are kind of aggregating for a large number of those

independent threads of time, just like we're aggregating the effect of lots of different molecules in a gas or lots of different atoms of space in space time, we're aggregating the effects of many different threads of time. So the kind of strange set up is our minds. Operating on many threads of time. And those threads of time are continuously branching and merging and so on. But our minds essentially are large, just as we're large compared to individual molecules. We're large compared to the atoms of space. We're also large in what we call bronchial space,
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the space of these possible branches of history. We we span many branches of history. And it is our kind of belief about the world that we can just aggregate those branches of history and say something definite happened. And when we see the the edges of that, that's when we see quantum effects. Quantum effects are sort of where, where it doesn't quite it hasn't quite had time to match up. We don't quite get to do that conflation of all those different threads of

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(08)- case that's kind of outside the electron. ?? And when we look at it as observers like us, it seems like the electron can move around without changing. Like a vortex in a fluid. You have this little ring. And for example, in water, that vortex can move around with the water, but as it moves, it uses different molecules in the water to create itself. And it's the same with an electron or a black hole. It uses different atoms of space to create itself as it moves. By the way, it has its own interesting consequence, which is something that comes up in relativity, which is that if you think about it moving in space and it's basically how it moves, it has to reconstruct its structure at a different place in space. And this process requires some kind of computational work,
35:08
the actual process of kind of progression of things through time. ?? Let's say it's some kind of clock, that the progression through time uses computational steps to create the text of the clock. ?? So what happens is that if a thing moves, then motion requires a certain amount of computation to achieve it. Reconstructing a thing at another location in the universe requires a certain amount of computation. So if a thing has a limited amount of computation, a fixed amount of computation, it has a trade-off between using its computations to evolve for itself over time, and using its computations to reconstruct itself, at different locations in space. And is the physicist doing all this "for himself" or is the Universe doing it "for itself"? (and are we just "spying on" it?). So if you move faster in space, you progress, you evolve in time more slowly. In other words: the finding according to STR: no matter how fast you fly at v → c, the rate of time "around the rocket and in the rocket" is still the same.. And that this is essentially the story of time dilation. Time dilation 'on the rocket' is observed in his observatory only by the basic Observer by reading information from the rocket. The commander of the rocket does not observe any dilation "on himself" even when he changes his speed. Logic leads to the fact that the Observer on the quasar on the observability horizon also observes us and evaluates our speed (relative to him) as v = 0.99c, and therefore time should go terribly slowly for us = dilated. But that is not the case.
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I mean those, those, data, which is really great, that it is some kind of mechanical explanation of time dilation. Mechanical??, what is it? Explain dilation honestly and realistically. Physicists misinterpret STR. This is not any dilation or contraction "on the observed object",

but it is (according to STR) the detection of a rotation of the systems (the Observer system and the system of the observed object) because the rocket changes its uniform motion **v = const**. For non-uniform motion **"a" = const.** and **"a" = non-const.** Otherwise, the sequence v_n → c. could not occur. The speeds vn are just "stop states" of the rocket in a rotated frame, because it **during accelerated motion it moves through curved space-time** – see Mr. Einstein's OTR. Now there
gets, you know, the whole story, because you're actually dealing with these causal graphs, not just some kind of fixed structure of space. So you end up getting into some kind of traditional sensory invariance, ?? fabrications… and things like that. I mean, it's, I think, you know, a thing, just to finish this idea, this really remarkable fact, as far as I'm concerned, that the kind of thing that we perceive in space is actually just a consequence of the fact. of motion in curved spacetime in which the rocket rotates its own frame; that's the "remarkable" fact that underneath that is computational irreducibility. Reducibility or irreducibility are just excuses for physicists for not finding – not finding out the true reality… And we are observers who are computationally limited. ? If we weren't computationally limited, would we observe what?, more (true) reality? And actually there's **one more characteristic** that we have to have to get general relativity and quantum mechanics<, and that is that we have to believe that we are persistent in time, even though we are made up of different
37:02
atoms of the universe at any given moment. You and I believe that we are the same now as we were a second ago. We are not the same, but the change "in a person" is not so substantial that it cannot, to limit, observe the "correct" reality. That's how we, in a sense, pass through the universe, assuming that it is the same us at successive moments in time. O.K. Persistence of memory. Right. Correctness, that the fact that we treat it as if it were the same us. We don't say it is and that's very important. And well, both in general relativity and in quantum mechanics and quantum mechanics, the key thing that's happening in this is again about time in this rewriting, this hypergraph and all these kinds of things. It turns out that there are many different ways how to rewrite. What to rewrite and why? And each different set of rewrites essentially defines a different thread of history, a different kind of thread of time. Each of these different sequences of rewriting corresponds to a different history of the universe. Okay, but what is it for, what is it leading to, what is it going to give us? And the non-trivial thing is that we believe

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we are persistent in time and we believe that we have a single thread of experience and time. We have to merge all these different threads of history into a single kind of the single thread of experience that we have. And then what? Deeply analogous to what happens in both dynamics and spacetime, that in a way we aggregate a large number of these independent threads of time, just as we aggregate the effect of many different molecules in a gas or many different atoms of space in spacetime, we aggregate the effects of many different threads of time. And that leads to what? To improve what? Calculations or observations? So that kind of strange setup is our mind. Operating on many threads of time. And those threads of time are constantly branching and merging and so on. Branching and merging..er… this “knowledge” tells us what? But our minds are essentially big, just as we are big compared to individual molecules. We are big compared to the atoms of the universe. We're also big on what we call bronchial space,

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the space of these possible branches of history. We deal with many branches of history. I have "my" history, and you have "your" history, and Franta has "his" history. So what about that? Does that help us to understand the Universe? How. And it's our kind of belief about the world that we can just aggregate these branches of history and say that something happened. If we didn't aggregate, (and didn't know that there was some aggregation), wouldn't we know what happened? And when we see the edges of that, we see quantum effects. ?? Quantum effects are kind of where it doesn't quite work, it didn't have time to align. We can't make the connection of all these different threads

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(09)- history. And for example, one of the things that I actually understood until quite recently is sort of one of the features of quantum mechanics is one's always saying, oh, there's randomness in quantum mechanics, you kind of don't know what's going to happen. It's probabilistic. cause of that in these models is, is kind of the same thing as the cause of the fact that the view that we have of the universe is a consequence of the fact that we're sitting here on this planet. If we were somewhere else in the universe, we would have a different view of what was happening in the universe. Same physical laws,
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but the sky would have different things in it from some other part of the universe. Well, in branch space and the space of possible histories, it's the same thing. We I mean, we agree on things about the night sky because we're all sitting on this one planet. Well, we agree about things that happen in quantum mechanics because we are all sitting very close together in bronchial space. There's a just like there is. We could imagine that some, you know, some alien critter sitting on some star the opposite side of the galaxy has a different view of the details, not of the laws of physics, necessarily, but of what's actually happening in the universe. So similarly, the fact that there is this apparent randomness in quantum mechanics as a consequence of the fact that we we don't know, sort of from a priori where we are in branch space,
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just like the fact that we're on this planet rather than some other planet is, you know, we can trace back the history of that. But there's no kind of theorem, there's no theory that says, we've got to be on this planet, not on another planet. And that's kind of the source of this kind of lack of that. There's there's this kind of lack of knowledge, this kind of randomness about what happens that comes from the fact that we are in a random place and branches of space, so to speak. Speaking of those, like, random randomness, I immediately could not be dissuaded from thinking about Boltzmann brains and sort of this, random fluctuation. That could be maybe the simplest, imaginable, unconscious observer or computationally possible observer. Is that true? I mean, think of them as even more simple than electrons, which, you know, there's this whole controversy of whether or not, inanimate objects are conscious, or participate in the consciousness project, so to speak, called panpsychism. And there are many people that do believe that many eminent, philosophers, for example, I find it kind of absurd,
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but but I want to ask you, Boltzmann brains, are they the atoms of consciousness? whole idea of sort of what is capable of intelligence is something I've. I mean, I sort of talked about for 40 years or so, and it's it's it's found its way into a bunch of philosophy of science as well. So the key thing to realize is there's this thing I call the principle of computational equivalence.

You might have thought that if you had a system with very simple rules, it would not be capable of doing anything as sophisticated as something like a brain does. But it isn't true the sort of sophistication of the computation that can happen even in a system with very simple rules is just as great as what can happen in a brain. And in fact, we've kind of got a lesson in that from looking at AI and large language models and so on. But they're just kind of computational systems, and yet they do very brain like things. That's just an example of that, that phenomenon, so to speak. So getting the capability of sophisticated
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computation of intelligence is not difficult. The issue is, is that intelligence aligned with our intelligence. So I like to think about it in terms of what I call rules space. It's essentially the space of all possible kinds of rules by which you could describe what's going on in the universe, and different human brains are pretty close together in really all space. the details of how we think about modeling the universe are different, but it's close enough. We can communicate. We can package up our thoughts by doing the analog of making particles. We we make up words and concepts. We use human language to take all those complicated neuron firings and in one brain, package it up, transmit it to another brain, be able to unpack it in that other brain and have something which is reasonably aligned with what the first brain was thinking, so to speak. So the way to think about it is sort of human brains, human minds are pretty close together in space.
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Then you've got to the cats and dogs and things like that, that further away there are a few things sort of, you know, features of sort of emotional response that are, that are in the, in common. Then we get to things like the weather, which people, you know, will sometimes

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(09)- history. And for example, one of the things that I really understood until recently, which is kind of one of the properties of quantum mechanics, is that you keep saying, oh, in quantum mechanics there is randomness, you kind of don't know what's going to happen. We often know what's going to happen (sometimes even a fortune teller knows), but we can't find the mathematics that would write down the "stop state" of what happened/will happen/happened... It's likely. The cause of that in these models is kind of the same as the cause of the fact that the view we have of the universe is a consequence of the fact that we're sitting here on this planet. **?** If we were somewhere else in the universe, we would have a different view of what's going on in the universe. That's logical... Same laws of physics,
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but there would be different things in the sky than in another part of the universe. The observer in a black hole doesn't know what's "out there" outside the hole and... and we know... heh heh... Well, in branch space and in the space of possible histories, it's the same thing. I mean, we agree on things about the night sky because we're all sitting on this one planet. Well, we agree on things that happen in quantum mechanics because we're all sitting very close together in bronchial space. It's there exactly as it is. We could imagine that some, you know, some alien creature sitting on some star on the other side of the galaxy has a different view of the details, not necessarily the laws of physics, but what's actually happening in the universe. Likewise, the fact that in quantum mechanics there is this apparent randomness as a consequence of the fact that we don't know, somehow a priori, where we are in the branch space, still there in the subtext is that Heisenberg and his "uncertainty principle", but

understand that it can be changed to a "certainty principle". (I know how). Then...then what takes precedence?

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just like the fact that we are on this planet rather than some other planet, is, you know, we can trace the history of that. But there is no kind of theorem, there is no theory that says we have to be on this planet, not on some other planet. One theory I would have : https://www.hypothesis-of-universe.com/docs/aa/aa_037.pdf and in English it is the same here https://www.hypothesis-of-universe.com/docs/eng/eng_009.pdf ; or pyramidal genesis, which is based on the principle of alternating symmetries with asymmetries and on the expression of the equation "value times quantity is constant... And that's kind of the source of this kind of lack. There's this lack of knowledge, this kind of randomness about what's going on, which comes from the fact that we're in a random place random spatially, but not developmentally, there we are at the peak of complexity, at the tip of the pyramid... and the branches of the universe, so to speak. Speaking of this seemingly random randomness, I couldn't help but immediately think about Boltzmann brains **?** and some kind of random fluctuation. That could be perhaps the simplest, imaginable, unconscious observer or computationally possible observer. Is that right? I mean, consider them even simpler than electrons, which, you know, is this whole controversy about whether or not inanimate objects are conscious or participating in a consciousness project, so to speak, called panpsychism. I think not. The electron is a "package, a ball" that the Universe "invented" right at the beginning after the Big Bang and since then they (electrons) are clones unchangeable, forever. https://www.hypothesis-of-universe.com/docs/ea/ea_002.pdf ; And there are many people who believe that many important philosophers, for example, I find absurd,

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but I want to ask you, Boltzmann brains, are they atoms of consciousness? It doesn't matter what you call it, and you can feel free to consider this abstraction as reality… The whole idea of what intelligence is capable of is something I have. I mean, I've been talking about it for about 40 years, great, I appreciate that… and it's found its way into a lot of philosophies of science as well. So the key thing to realize is that there is|| this thing I call the principle of computational equivalence. I'd appreciate a more comprehensive explanation… You might have thought that if you had a system with very simple rules, it wouldn't be able to do anything as sophisticated as something like a brain. But it's not true that the kind of computational sophistication that can happen even in a system with very simple rules is as great as what can happen in a brain. And we actually learned a lesson from that in terms of AI and big language models and so on. But they're just kind of computational systems, and yet they do things very similar to the brain. That's just an example of that, of that phenomenon, so to speak. So getting the ability to have sophisticated

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computational intelligence is not difficult. The problem is that intelligence is consistent with our intelligence. So I like to think about it in terms of what I call the rule space. It's basically the space of all possible kinds of rules, over time new more rules emerge... that you could use to describe what's going on in the universe, and different human brains are pretty close to each other in really all of space. The details of how we think about modeling the universe are different, but it's close enough. We can communicate. We can pack our thoughts together by making an analogy of particle formation. We invent words and concepts. We use human language to take all these complicated neurons and pack it up in one brain, transfer it to

another brain, be able to unpack it in that other brain and have something that is reasonably consistent with what the first brain was thinking, so to speak. So the way to think about it is, human brains, human minds are pretty close together in the universe.
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Then you get to cats and dogs and things like that, that there are a few things, you know, features of kind of emotional responses that are, that are common. Then we get to things like weather, which people, you know, sometimes will

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(10)- quip, you know, the weather has a mind of its own, but the fact is that the sort of the dynamics of fluid of, of air and, and clouds and the atmosphere and so on is just as computationally sophisticated as the things that are going on in the neuron firings in our brains. It's just that what happens in the weather is pretty far away in space from where we are. It's not well aligned. We can't sort of say, oh, we understand the purpose of the weather and so on. Now, when it comes to kind of what is consciousness, so to speak, I think for me, one of the things that's been important in terms of nailing that down is to say, well, why do we care? Well, one reason we care is that consciousness is sort of a feature of observers like us.
45:02
And it seems that things like this, this kind of single thread of experience, that's all very tied up with observers like us. I mean, just to explain, you know, I've tried to develop what I call observer theory, which is kind of a general theory of observers, analogous to the general theory of computation that one has about computational systems and sort of the key thing about observers is they filter all the data that's coming in to them to kind of take all the complexity of what's out there in the world and kind of compress it to the point where it can be stuffed into a finite mind. So, for example, when you are doing, you know, we're we're looking around at, you know, this scene of, of, whatever we're looking at and maybe there, you know, I don't know I don't know what it is. 100 million photons, that, you know, affect the receptors in our eyes every second. But yet we don't pay attention to all of those details.
46:01
We just pay attention to some overall thing about, well, there's a, you know, there's this object in front of me and things like this. So we are deeply compressing the sort of raw data of the universe to stuff it into our finite minds. And that's kind of the essential feature of observers. Observers have this feature that they're equivalence together, many states of the world, and they care about only certain aggregates, states of the world. So there are many systems that do that kind of equivalent thing. And what? The inner experience of such a system is, is, I mean, that's a that's sort of a complicated philosophical thing to untangle, but essentially the, you know, the operationally, the key feature of observers like us, we're computationally bounded, we have finite minds, and we believe we're persistent in time. And I think that notion of kind of that single aggregated thread of experience, you know, operationally is important. You know, when you say, is that person conscious? You know, you're doing a neurophysiological assessment of a no neurological assessment of, is that person conscious? A lot of it has to do with do they, do they kind of aggregate together all those sensory inputs and have a definite sort of thread of experience, a definite sort of thread of attention and so on. this question of what does it take to have a thing that's doing equivalent thing. It's a little bit of a complicated turtles all the way down story. Because to know that you have a thing that's doing equivalent thing, you have to have an observer of that equivalence thing. And so you end up with this kind of chain of observers kind of all the way down. And that's a at some point you're kind of

asking, you know, is the does there emerge a thing in some particular kind of system that does this kind of equivalent thing. Can you notice that there's a thing with this kind of equivalence thing for which you have to have another level observer and so on.
48:01
But one of the things we we I've been working on actually, recently is the following thing. So, so one of the things we didn't quite talk about is the, the deepest part of the rabbit hole, as far as, as far as I'm concerned, is this thing we call the roulade, which is kind of this entangled limit of all possible computations. It's what you get. It's the universe is running all possible rules at the same time, so to speak. It's this it's this thing that is sort of the unique object that is the result of running all these rules and running them in all possible ways. And that thing, it's very interesting because that thing sort of inevitably exists. That thing is just a formal object that must exist. And so when we, we have to be embedded within that object. And what we are asking is, how does an observer like us perceive what's going on in the really ad? And the whole big point is that given those characteristics of us as an observer, we necessarily see the laws of physics that we have,
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you know, discovered in the 20th century and so on, which is pretty amazing that it's possible to say you can now, if you say, what does an observer not like us perceive in the universe?

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(10)- The joke is, you know, weather has a mind of its own, but the fact is that the kind of dynamics of fluids, of air and, of clouds and atmosphere and so on, are just as computationally sophisticated as the things that happen in the neurons in our brains. It's just that what happens in weather is quite a distance away in space from where we are. It's not well-aligned. You can't say that we understand the purpose of weather and so on. Now, when it comes to what consciousness is, so to speak, I think one of the things that was important in order to be able to do that is to say, why do we care about it? One of the reasons why we care about it is because consciousness is something of a feature of observers like us.
45:02
And it seems that these kinds of things, this kind of single thread of experience, all of this is very much tied to observers like us. I mean, just to explain, you know, I've tried to develop what I call observer theory, which is a kind of general theory of observers, analogous to the general theory of computation that one has about computing systems, and kind of the key thing about observers is that they filter all the data that comes to them to take all the complexity of what's out there in the world to the point where it can be compressed into a finite form. So for example, when you do, you know, we look around, you know, this scene, whatever we're looking at and maybe there's, you know, I don't know, I don't know what it is. 100 million photons that, you know, every second are impacting the receptors in our eyes. But yet we're not paying attention to all that detail.
46:01
We're just paying attention to some overall thing around, well, there's, you know, this object in front of me and things like that. So we're deeply compressing the kind of raw data of the universe to cram it into our finite minds. And that's kind of a fundamental feature of observers. Observers have this property that they're equivalences together, many states of the world, and they're only interested in certain aggregates, states of the world. So there are many systems that do similar things. and what? The internal experience of such a system is, is, I mean, this is kind of a complicated philosophical thing to unravel, but basically, you know,

operationally, a key feature of observers like us, we're computationally limited, we have finite minds, and we believe that we're persistent in time. And I think the idea of kind of that single aggregate thread of experience, you know, operationally is important. You know, when you say, is this person conscious? You know, you do a neurophysiological exam without a neurological exam, is this person conscious? It has a lot to do with what they're doing, whether they're somehow aggregating all of that sensory input together and having a certain kind of experience, a certain kind of attention, and so on. this question of what it means to have a thing that does equivalent things. It's a bit of a complicated turtle story. Because in order to know that you have a thing that does equivalent things, you have to have an observer of that equivalent thing. And so you end up with this kind of chain of observers kind of all the way down. And so at some point you ask, you know, does a thing appear in any particular kind of system that does this kind of equivalent thing. You might notice that there's a thing with this kind of equivalence for which you have to have a different level observer and so on.
48:01
But one of the things that I've been working on recently is this thing. So one of the things that we haven't really talked about is the deepest part of the rabbit hole, as far as I'm concerned, is this thing we call the roulade, which is this kind of intricate limit of all possible computations. That's what
you get. The universe has all the possible rules at the same time, not all of them are activated at once .., so to speak. It's this thing that is kind of a unique object that is the result of triggering all these rules and triggering them in all possible ways. And that thing is very interesting because that thing kind of inevitably exists. That thing is just a formal object that has to exist. And so when we, we have to be built into this object. And we ask, how does an observer like us perceive what's going on in the real ad? And the whole point is, given these properties, we as observers necessarily see the laws of physics that we have,
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You know, discovered in the 20th century and so on, which is quite amazing, that it's possible to say that now you can, if you say, what does an observer like us perceive in the universe?

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(11)- Well, that's could perceive very different things, even as I mentioned, you know, an observer thinking a million times faster than we do. But in a, in a, in a region of space of the same scale that we're at, will perceive a very different kind of set of things to be happening. And I think that the, it's very hard. I put some considerable effort into this to imagine what it is like to be an observer, not like us. And in fact, here's one way to think about it. So I have some some fun pictures of what happens if you just use generative AI and you say, here's generative AI set up to be just like us, and you tell it, make a picture of a cat and it'll make a nice picture of a cat. And then you'd say, make a picture of a dog.
50:01
It makes a picture of a dog. But there is an inter concept space between the picture of the cat and the picture of the dog. There is a set of kind of pictures that, in a sense, this abstract mind can imagine that the mental images of an alien mind. those mental images, those those things between the cat and dog and so on are are things that are constructible for a mind, but not what our human minds are used to. And I've been referring to that as into concept space. So we have concepts like cat and dog and in between there is into concept space. And the space that we have populated with concepts with the 50,000 words in typical human languages and so on. The the region that we have populated effectively in the Iliad is absolutely

infinitesimal. In other words, there's a there's a huge kind of into concept space relative to kind of the tiny places

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where we have sort of colonized an entire concept space. that's one little way of getting a little tiny peek of what it's like to be an observer, not like us, actually. Some of what I've done in long time work and what I call really ology, the study of sort of arbitrary simple rules in the computational universe. There's one other views of kind of what rules that are not like the rules we attribute to the universe what they do. That's sort of another way to get a sense of what observers not like us. We'll we'll we'll see. But one of the questions, I mean, coming back to time for a second, one of the things that may be a bit confusing is in this rule and object we talk about, it's the limit of all possible computations. It's this thing that represents the progress of all possible computations. So you say, well, that's just a thing that exists. So that means that all of time has already happened. In other words, we have this object that represents

52:04

the whole history of the universe. All of space, all of time. Everything that happens in the universe is inside this really odd object. So you might say, why then do we experience sort of time as a progression? Why? Why isn't it just we've got this big gulp? All of time is right there. The reason is because we are computationally bounded. We are only able to explore this really hard kind of one step at a time. For observers like us, we can't take a big gulp of the really, and it's just not it doesn't fit in our finite minds. If we had infinite minds, we could fit the whole really odd in our minds. But because we have finite minds, we're stuck kind of walking through the really odd kind of one tiny step at a time. And that's why we perceive that to be a progression in time rather than just, it's, it's this way that's that's all of what there is in time. hey, I know if you're enjoying this conversation,

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you'll love my Monday Magic mailing list where I send out the greatest information in the known universe but everything. It's fascinating to me. Your friendly neighborhood cosmologist. I'll even be writing about this episode, so go to Brian King eCommerce list. You'll also be entered to win real live meteorite. I give them out to 1 or 2 lucky winners every month, but if you have a.edu email address, you're guaranteed to win kind of ranking economy edu career blast with a edu email address. Now back to the episode. I wonder if we could pivot to now, away from the observers into a realm that

The role of gravity in the computational universe

both thermodynamics, temperature and time play a big role in. That's the way the bread gets buttered around the Keating household, which involves the cosmic microwave background radiation. And I thought we. Yeah. So I thought we'd take a quick detour and explain the role of, of gravity, the role the gravity plays in the rules and in, in computational universe. So talk about, well, be familiar to my physics, physics audience.

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Physically, inclined audience, shall we say, will be most understood, Stephen, if you explain it in terms of the way that the hypergraph activities depend on energy and momentum, then

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(11)- Well, it could perceive very different things, even as I mentioned, you know, an observer thinking a million times faster than us. But in a, in, in the same scale of space that we are in, it will perceive a very different kind of set of things that are happening. And I think that's very hard. I've put a lot of effort into it to imagine what it's like to be an observer, not like us. And actually, here's one way to think about it. So I have some fun pictures of what happens when you just use a generative AI and you say, here's a generative AI set up to be like us, and you tell it, take a picture of a cat, and it takes a nice picture of a cat. And then you say, take a picture of a dog.

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It takes a picture of a dog. But there's an in-between space between a picture of a cat and a picture of a dog. There's a set of kinds of images that this abstract mind can imagine, in a sense, as mental images of another mind. These mental images, these things between cat and dog and so on, are things that are constructible to the mind, but not what our human minds are used to. And I talked about this as conceptual space. So we have concepts like cat and dog, and in between is conceptual space. And the space that we've filled with concepts with 50,000 words in typical human languages and so on. The area that we've effectively populated in the Iliad is absolutely infinitesimally small. In other words, there's a huge kind of conceptual space here compared to the kind of small places

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where we've kind of colonized the whole conceptual space. That's one small way to get a little glimpse of what it's like to be an observer, not like us. Some of the things that I've been doing for a long time, and what I call really ologies, the study of kind of arbitrary simple rules in a computational universe. There's another way of looking at what rules are not like the rules that we attribute to the universe, what they do. That's another way of getting an idea of what observers don't like about us. We'll, we'll see. But one of the questions, I mean, going back in time for a second, one of the things that can be a little confusing is in this rule and the object that we're talking about, it's the ||limit of all possible computations. It's this thing that represents the progress of all possible computations. So you say, well, this is just a thing that exists. That means all time has already happened. In other words, we have this object that represents

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the entire history of the universe. All of space, all of time. Everything that happens in the universe is inside this really weird object. So you could say, why do we experience time as a progression? Why? Why don't we just take a big sip? All of time is right there. I don't know from the narration here whether the author understands time as I do. Even though the title of this article is "WHAT IS TIME," the author hasn't told me that until now... (he hasn't told me his version). The reason is that we are computationally limited. We can only explore this really hard kind of thing one step at a time. For observers like us, we can't really take a big sip, and it's not like it can't fit into our finite minds. If we had infinite minds, we could fit it all into our minds in a really weird way. But because we have finite minds, we're stuck going through this really weird kind of thing one little step at a time. And that's why we see it as a progression through time, rather than just, it is, it is this way, that is all there is in time. I'm losing my mind >understanding< the author... hey, I know if you like this interview,

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you're going to love my Monday Magic mailing list, where I send out the biggest information in the known universe, but everything. **It's fascinating to me**. It's fascinating to you because you made it up for yourself. It's not fascinating to the cleaning lady. Your friendly neighborhood cosmologist. I'll even write about this episode, so head over to **Brian King's** e-commerce list. You'll also be entered into a contest to win a real live meteorite. I give them away to 1 or 2 lucky winners each month, but if you have a .edu email address, you're guaranteed to win some kind of edu career economics. Now back to the episode. I wonder if we could turn now, away from observers, to the realm that **The Role of Gravity in the Computational Universe** both thermodynamics and temperature and time play a big role. That's how bread is buttered in the Keating household, which involves the cosmic microwave background. And I thought we would. Yeah. So I thought we'd take a quick detour and explain the role of gravity, the role that gravity plays in the rules, or the rules in gravity?? and in the computational universe. So talk about that, okay, be familiar to my physics, physics audience.

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A physically inclined audience, let's say, will understand best, **Stephen**, if you explain it in terms of the activities of the hypergraph depending on energy and momentum, then

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(12)- we'll get into gravity and how it emerges, and then we'll look at two specific cases black holes and the possible singularity at the origin of the universe. And that'll be a prelude to talk about time and the evolution of the CMB. So please, Stephen, hyper graphs and energy momentum. How are they connected? so we've got this graph. And the graph connects atoms of space. These atoms of space are not laid out in space. There isn't any space yet. This network defines space. So it's as if all we know is what the friend network of the atoms of space is. All we know is who's friends with who? We In social graph. Right. then happens is when you have a sufficiently large such graph, you can start saying, well, actually we can think of this as,

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as we can we can imagine laying out all these atoms of space in a way that is like our familiar structure of space. So, for example, one of the things that's quite non-trivial is the dimension of space is something that's not defined by this graph. The dimension of space has to emerge by looking at something like you start from one place in the graph and let's say, let's say you've got all your friends and all your friends live in a city which is arranged on a grid. Then it will be the case that if you start with one person and you say, how many friends do they have? One mile away, two miles away, three miles away, the number of friends will go up like the square of the distance, just because it's the area in two dimensions. If instead these were, you know, if instead I don't know the that this was plankton in the ocean where it's three dimensional and it was kind of like friends and plankton in the, in the plankton village, so to speak. Then this, this sort of how many friends do you get to a certain distance away would go up like the volume of a of a sphere r cubed. And so that's the way that you start getting from this. From the structure of this graph, you start getting things like what's the effective dimension of this graph. And by the way, one of the big predictions of our models is that there will be dimension fluctuations. In other words, that dimension of space is not exactly three. In fact, a strong suspicion is that in the beginning of the universe, the dimension of space was infinity, and that only as as sort of the universe in effect progressed to the effective, dimension of space end up cooling down to be roughly three. And there's a big question of whether there are dimension fluctuations left over from the other universe. That will be a spectacular thing to see in the CMB, and I'd love to know details. Well, we can, but we'll get to that in a Yeah. so we're talking about kind of space. We can define things like what's a straight line in space.

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We're kind of going through this graph looking at the shortest path from one friend, let's say, to another from one atom of space to another. And that defines so-called geodesic, a shortest path in the graph, a shortest path in space. Okay. So so now what's energy? You know, I have to say I was really surprised by how simple it ends up being. Energy is basically the amount of activity in the graph. It's the number of rewrites that are happening in a particular region of the graph. Now, that's a slippery concept because we don't have a notion of space yet. So the notion of what's the density of rewrites depends on how much space there is there. And so there's a slightly more that the more formal thing is to look at this causal graph that I mentioned before. And to ask, as you look at that causal graph and you have a space like hyper surface that's defined a slice through the causal graph that defines the simultaneity surface. The energy is the flux of causal edges
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that poke through that space, like hyper surface and momentum is the flux of cores. Alleges that poke through a time like hyper surface which is orthogonal to that. And so as you change your reference frame, which is as you change how you define some alternative surfaces, as you change your reference frame in relativity, you are changing the the way that those those causal edges poke through the space like hyper surfaces. So one very nontrivial fact, which is not explained in standard relativity theory, is that the relativistic transformation of space and time is the same as the relativistic transformation of energy and momentum and our models. That's something that necessarily falls out from the fact that we think about space as the steady six and the hypergraph and time as the sequence of events and then the, the, the density of, of, of causal edges
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is energy and and so, so then what happens is, here's how gravity works, which is, again, totally remarkable that that's an almost mechanical description of this. So you have a shortest

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(12)- we'll get into gravity and how it emerges, and then we'll look at two specific cases of black holes and possible singularities in the formation of the universe. And that's going to be a prelude to a conversation about time and the evolution of the CMB. Finally, "about time." So please, Stephen, hypergraphs and momentum energy. How are they connected? So we have this graph. And the graph connects the atoms of space. These atoms of space are not distributed in space. There is no place yet. This network defines space. So it's like all we know is what the network of friends of the atoms of the universe is. We just know who's friends with whom? Us in the social graph. Right. Right. Then what happens is when you have a big enough graph like that, you can start to say, well, we can actually think of it as,
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how can we imagine that we distribute all these atoms of space in a way that's like our familiar structure of space. So for example, one of the things that is quite nontrivial is the dimension of space, meter to the third = meter^3 (three perpendicular dimensions x^3)...right?! which is not defined by this graph. I don't have a video playing. The dimension of space has to come up by looking at something like if you start at one place on the graph and say you have all your friends and all your friends live in a city that's arranged on a grid. Then it's going to be like if you start with one person and you say how many friends does he have? One mile away, two miles away, three miles away, the number of friends is going to go up as the square of the distance, just because it's an area in two dimensions. If instead of that, you

know, if instead of that, I don't know, it was plankton in the ocean where it's three-dimensional, and it was kind of like friends and plankton in a plankton village, so to speak. Then this kind of how many friends you get within a certain distance would grow like the volume of a sphere r cube. um… And so you start to get out of it. From the structure of this graph you start to get things like the effective dimension of this graph. And why? And by the way, one of the big predictions of our models is that there will be a fluctuation (*) of dimensions.?? What is that? In other words, the dimension of space x^3 is not exactly three. Ah… You mean "fluctuation of the number of dimensions", like there are sometimes 2.9 … right? In fact, there is a strong suspicion that at the beginning of the universe the dimension of space was infinite, nonsense! a cow is still a cow and she can't be 'initially' infinite and that only as the universe actually progressed into the effective, the dimension of space ended up cooling down to about three. Sir, the number of dimensions, I think you mean. Yes, the number of dimensions of infinity can gradually be reduced to 3 dimensions. Yes…, my model says that the first three dimensions (both time and length) are physical reality and the higher dimensions (in the demonstration of string theory) are mathematical dimensions (up to infinity). And there is a big question whether there are dimensional fluctuations left over from another universe. Um, there is a question whether there is Hell and devils in it on other planets… That will be a spectacular thing to see in the CMB and I would like to know the details. Well, we can, but we will get to that later. So we are talking about a kind of space. Well, if 2.9 dimensions are a "kind of space" for you, then you are out of line and I have nothing to talk about with you. We can define things like what a straight line is in space. Maybe a perforated straight line is also a perforated dimension for you…um…

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We're going through this graph and we're looking at the shortest path from one friend, let's say, to another from one atom of space to another. And that defines what's called a geodesic, the shortest path in the graph, the shortest path in space. Okay. So what is energy? You know, I have to say I was really surprised at how simple it actually is. Energy is basically the amount of activity in the graph. And... and so there are graphs flying around in the universe and in the Sun... It's the number of rewrites that occur in a certain region of the graph. That's a slippery concept because we don't have a concept of space yet. You might not have a concept of rewrite density yet... So the idea of rewrite density depends on how much **space**, spatial? (or non-spatial, computational?) there is. And so there's a little bit more, the more formal thing is to look at this causal graph that I mentioned earlier. And let me ask, if you look at that causal graph and you have space as a hypersurface, abstractly it may be, but why. Why build cages for thieves in Hell (?) which is defined as a cut through the causal graph that defines the simultaneity surface. Energy is flow of causal edges, and the singing of an opera singer is the creaking of a boiler door in Hell…

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which penetrate this space, like a hypersurface and momentum is flow of nuclei. Um… and angular momentum is *stop-state flow* (nuclei)… A statement that penetrates time like a hypersurface that is orthogonal to it. And so when you change your frame of reference, which means you change the way you define some alternative surfaces, when you change your frame of reference in relativity, you change the way these causal edges penetrate space as hypersurfaces. So one very non-trivial fact that is not explained in standard relativity is that **the relativistic transformation of space and time is the same as the relativistic transformation of energy and momentum** and our models. Well, that's what I'm interested

in relativistically. Please tell me "where/how/into what" energy is 'relativistically' transformed", i.e. momentum. And similarly "how/into what" space is relativistically transformed, i.e. time. (!) That's already a gibberish, drowned in a fable. That's something that necessarily falls out from the fact, um…you got it wrong… that we think of space as a fixed six and of a hypergraph and time as a sequence of events and then of the density of causal edges.
59:04
is energy and so, so that's how gravity works, which is again absolutely remarkable, that it's almost a mechanical description of this. I had a feeling that "this" is mechanically "this" and "this" is mechanically "this" and "this" is mechanically "this" and "this" is mechanically a description of "this"... almost... So you have the shortest

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(12)- path in the graph. And that's defined by just looking at the graph and just saying, how do I go from, from outer space to atom of space in the shortest path. Well, when there is activity in the graph that deflects that shortest path, it changes the shortest path. It's changing the structure of the graph. It changes where the shortest path is. It changes it according to the Einstein equations. Basically that basically the presence of energy momentum deflects these geodesics in the graph. I mean, just as a as a fun fact. Okay. The one thing you might ask is, years ago, when I was, when I was first working on and so the precursors of this physics project, there was
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a, person mathematician who worked with me, and, he would tell people from time to time, oh, I'm working on, you know, fundamental theory of physics. And so on. And they would think, oh, you're kind of nuts. And they would say things like, and so are you going to invent warp drive? so now the question is, now that we think we really do understand the sort of machine code of physics is warp drive possible? In other words, is it possible to go faster than light? And turns out that in some sense it is. So here's how this works. It's actually deeply related to things like the second law of thermodynamics. Again, let's tell a story about the second law of thermodynamics. We've got all these gas molecules bouncing around in this room that going at about the speed of sound. But yet if I were to, you know, release some, some sent, you know, in this place, in the room, it would diffuse very slowly to the other side of the room because it's being sort of carried on one molecule, then the next, then the next, or being kicked around by one molecule, then the next, then the next.
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But if we could figure out at a microscopic level, I want to hitchhike on this molecule now, then that's going to collide with another molecule. I'm going to jump to that other molecule. Then I'm going to jump to this other molecule. And I could figure out that path. I could go at the speed of sound across the room. So in other words, I could beat the usual structure of the gas I could make instead of going sort of the speed of diffusion on the gas, I could go at the speed of sound. The same thing happens in space time. If you could jump to exactly the right event in the structure of of this hypergraph, exactly the right rewrite event, you would be able to kind of surf through space faster than the speed of light. However, there's a problem. The problem is that you talked about, you know, an observer, a consciousness, for example, that very phenomenon of computational irreducibility tells you that things are so scrambled up that you will never be able to get a big thing

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through that, you know, that sort of surfing expedition. You'll, you know, at best, if you were a computationally unbounded observer, able to operate at the level of atoms of space, you could do that whole surfing thing. But as soon as you're a computationally bounded observer or an observer that has any of the attributes of us as as observers of the kind we are, we just don't fit through that very tiny kind of possibility of something between atoms of space. And so the fact that faster than light travel is impossible is the same statement as that the second law of thermodynamics follows, and that you can't turn heat systems into mechanical work. So insofar as you can turn heat into mechanical work, so similarly you can turn sort of the details of what's happening in this hypergraph into being able to go, you know, faster than light. So that was sort of a, a side thing. But but the main, the main thing, by the way,
1:03:06
I want to say something about the structure of the of, of this hypergraph and the relationship to heat. One of the things that I'm guessing right now. So one of the questions is, are we going to be able to see the discreteness of space? 100 years ago, 120 years ago, people were really lucky that molecules were big enough, that Brownian motion you could see Brownian motion through a microscope. And that wasn't obvious. Molecules could have been, you know, a million times smaller, in which case you wouldn't have been able to make that measurement. But we were lucky with molecules. So now the question is, what about the discreteness of space? What effect, what phenomenon could we look at that would reveal the discreteness of space? And one of the things that I kind of suspect is that there's already a phenomenon that's been known for a long time, which once we understand it, we'll say, oh, okay, it's obvious space has to be discrete. So just to tell an analogy to that, in the 1800s, people were
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(12)- path in the graph. And that's defined by just looking at the graph and saying, how do I get from space to an atom in space by the shortest path? Well, when there's activity in the graph that's deflecting that shortest path, it's going to change the shortest path. It's changing the structure of the graph. It's changing where the shortest path is. It's changing it according to Einstein's equations. Basically, the thing is, basically, the presence of momentum energy is deflecting these geodesics in the graph. So as a fun fact. Okay. The only thing you might ask is, years ago, when I was, when I was first working on the precursors to this physics project, there were
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a, a mathematician who worked with me, and from time to time people would say, oh, I'm working on a fundamental theory of physics. And so on. And they'd think, oh, you're crazy. And they'd say things like, so you're going to invent warp drive? So now the question is, now that we think we really understand the kind of machine code physics that warp drive is possible? In other words, is it possible to go faster than light? And it turns out that **in a sense** yes. So here's how it works. It's actually deeply related to things like the second law of thermodynamics. Let's tell the story of the second law of thermodynamics again. We have all these gas molecules bouncing around in this room, moving at about the speed of sound. But if I were to, you know, release some, send some, you know, at this point in the room, it would diffuse very slowly to the other side of the room because it's kind of carried on one molecule, then another, then another, or kicked by one molecule, then another, then another.
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But **if** we could figure it out on a microscopic level, I want to track this molecule now, then it collides with another molecule. I'll jump to this other molecule. Then I'll jump to this other molecule. And I was able to figure out that path. **I could** go at the speed of sound across the room. So in other words, **I could** beat the usual gas structure that I **could** create, instead of going at some kind of gas diffusion speed, **I could** go at the speed of sound. The same thing happens in spacetime. **If** you could jump to exactly the right event in the structure of this hypergraph, exactly the right rewrite event, **you would** be able to travel through space faster than the speed of light. If, if, maybe, I could, perhaps... However, there's a problem. The problem is that you talked about the observer, about consciousness, for example, that this very phenomenon of computational irreducibility tells you that things are so messed up that you're never going to be able to do anything big.
1:02:05
Though, you know, that kind of surfing. You're going to, you know, at best, **if** you were a computationally unconstrained observer, able to operate at the level of the atoms of space, **you could** do this whole surfing thing. But as soon as you're a computationally constrained observer or an observer who has any of the attributes of us as observers of the kind that we are, we just don't fit into that very small kind of possibility of something between the atoms of space. And so the fact that it's impossible to travel faster than light is the same statement as saying that the second law of thermodynamics follows and that thermal systems can't be turned into mechanical work. ?? So **if** you can convert heat into mechanical work, so similarly you can convert some of the details of what's going on in this hypergraph, **so that you can** be able to go, you know, faster than light. So that was kind of a side thing. But the main thing, the main thing, by the way,
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I want to say something about the structure of this hypergraph and the relationship to heat. One of the things that's on my mind right now. So one of the questions is, will we be able to see the discreteness of space? 100 years ago, 120 years ago, people were really lucky that molecules were big enough that you could see Brownian motion in a microscope. And that wasn't obvious. Molecules **could be**, you know, a million times smaller, in which case you wouldn't be able to do this measurement. But we were lucky with molecules. So now the question is, what about the discreteness of space? What effect, what phenomenon could we look at that **would** discovered the discreteness of space? And one of the things I kind of suspect is that there is already a phenomenon that has been known for a long time, and once we understand it, we say, oh, well, it is obvious that space must be discrete. You are sucking from a crystal ball, but there are physicists (prof. Kulhánek) who prove, defend the "quantization" of the length dimension (and therefore space)... https://www.hypothesis-of-universe.com/docs/c/c_477.jpg ; https://www.hypothesis-of-universe.com/docs/c/c_461.jpg ;
So to give an analogy to this, in the 19th century people were

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(13)- wondering what is heat?
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And people said, well, heat flows from one thing to another. What flows from one thing to another? Well, it's a fluid. It's something like color fluid. They defined. And that was the you know, that was the notion of what, what heat was what. Turns out he was actually the microscopic motion of molecules. Heat, the very phenomenon of heat, basically should have

told one that matter is discrete, that, that it isn't like a fluid flowing from here to there. It's the features of that microscopic structure. So now the question is, what is the phenomenon now that we already know that might reveal kind of the space time heat, that might reveal the similar features of the discreteness of space as the phenomenon of heat reveals the discreteness of matter. So I'm not sure. But my my current sort of, thing hypothesis to investigate is dark matter and possibly a little bit dark energy. But I think dark matter is really that really the story.

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And it's kind of amusing because when you say, I mean the phenomenon of rotation curves, of galaxies not being what you expected, that's been known for nearly 100 years. And, it's been something where, the what is it? Well, just like caloric fluid was thought of as a fluid because nobody could think of anything else that heat could be other than a fluid. So dark matter got the name matter because nobody could think of what it could be other than something, some kind of matter made of particles. I doubt that it's that. My strong guess is it's a feature of the structure of space, and my strong guess is that it's actually a, it's a it's a symptom of essentially space time heat. And it is possibly related to, to dimension fluctuations. And we usually think of in general relativity, we usually think of space as being curved. We don't think of it as changing its dimension,

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but that's actually surprisingly equivalent to the notion of changing dimension. It's that there's there's probably a duality between formulating general relativity in terms of curvature and in terms of dimension change. the only pushback I would put on that, Stephen, is that we do know dark matter

Dark matter and the discreteness of space

in particular form that's been detected. It's known as neutrinos. There every characteristic of dark matter they're weakly interacting. They're massive. They don't produce light. They don't interact with light or charge. So they would have to be some I'm not saying it's impossible to accommodate them in space time heat, but you have to accommodate neutrinos as well. we don't yet know about the neutrino background radiation. You know, it probably has. I remember working this out long ago. I think it's 1.6 kelvins. Was what, was, the temperature. And I for some brief time in the early 1980s, I thought maybe I had a way to detect low energy neutrinos using coherent scattering and helium in and superfluid helium in the a phase of superfluid helium three.

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And that was actually it was a very traumatic thing because at the time, if one had been able to detect that, one would have been able to detect nuclear reactors anywhere in the ocean from orbit. And this was the middle of the Cold War, and it wasn't obvious what you do with the knowledge that there's a physics way to detect where all the nuclear submarines are. was one of those cases where I was actually pretty happy that the science didn't work out, so I didn't have to solve the problem of, what do you do with that kind of information? but yeah, you know, I think neutrinos are, you know, they have all the characteristics of particles like photons and so on. They just had somewhat different interaction. And features of interaction. I mean, in fact. Okay. Fun fact, when I was a kid, aged probably 16 or so, one of my first, people that I never ended up publishing was about, neutrino background radiation, and it was about the possibility of, high density of neutrino background radiation because neutrinos, unlike photons, if you pack enough

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neutrinos have the exclusion principle because they're fermions have been half and so if you try and sort of pack too many energy neutrinos and they form this kind of, like, like the electrons in an atom, they kind of can only be a certain number of neutrinos in those states. So you end up with this kind of packed collection of neutrinos in the universe. And so I was wondering, how could you detect that and if that happened? You're absolutely right. They have huge gravitational effect. So then I can another trivia thing which led to my all time favorite nuclear isotope. So in those days, this was long before the web, long before Wolfram Alpha, long before all those kinds of things. I wanted to find out what? Well, in nuclear

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(13)- you wonder what heat is?
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And people said, well, heat flows from one thing to another. What flows from one thing to another? Well, it's a fluid. It's kind of like a colored fluid. They defined. And that was, you know, that was the idea of what, what kind of heat was what. Even a scientist should speak in more refined language, not just a secretary... It turns out that it was actually the microscopic movement of molecules. Heat, the very phenomenon of heat, was supposed to tell you, essentially, that matter is discrete, that it's not like a fluid flowing from here to there. They're features of that microscopic structure. So now the question is, what is this phenomenon that we already know could reveal a kind of spacetime heat that could reveal similar features of the discreteness of space, as the phenomenon of heat reveals the discreteness of matter. Yes, at the micro-level of Planck scales, there is both spacetime and matter in the "form" of granularity, discrete packages, loops on the time dimension and on the length dimension https://www.hypothesis-of-universe.com/docs/c/c_275.gif ; https://www.hypothesis-of-universe.com/docs/c/c_283.jpg ; and in spacetime, as combined packages, intertwined dimensions in the form of elementary particles and more into atoms, molecules of compounds, etc. So I'm not sure. But my current hypothesis to explore|| is dark matter and maybe a little dark energy. Wolfram dares… But I think dark matter is really the story. I'm against dark matter. There are more arguments against than for on the table.
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And it's quite funny, because when you say, I mean the phenomenon of rotation curves, where galaxies are not what you expected, that has been known for almost 100 years. And it was something where, what is it?. That's talking like an idiot...Well, just like the caloric fluid was considered a fluid because nobody could think of anything else, that heat could be other than a fluid. Dark matter|| was called matter, because nobody could think of anything else, that it could be other than something, some kind of matter made up of particles. I doubt that's what it is. My strong guess is that it's a feature of the structure of space, and my strong guess is that it is, in fact, a symptom of essentially spacetime heat. Well, you're mixing "gold with kerosene" and... and you're adding a little pepper, right? And maybe it has to do with dimensional fluctuations. Is this the idea that there could be 2.9 pieces in spacetime of those dimensions?..? And we usually think of general relativity, we usually think of space as curved. We don't think of it changing its dimension,
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but that is actually surprisingly equivalent to the idea of a change in dimension. This is incomprehensible gibberish. The point is >that there is probably a duality between the formulation of general relativity in terms of curvature and in terms of a change in dimension<.

Such a mouse-and-mash extra, isn't it? The only thing I would like to wish for this, Stephen, is that we know dark matter. I think Keating is already talking… Dark matter and the discreteness of space in a specific form that has been detected. It's known as neutrinos. There, all the properties of dark matter interact weakly. They are massive. They don't produce light. They don't interact with light or charge. So they would have to be some… I'm not saying they can't be contained in the space-time heat, but you have to include neutrinos. We don't yet know about the neutrino background radiation. It's hard to tell when Keating is speaking and when Wolfram is speaking… You know, he probably has. I remember thinking about it a long time ago. I think it's 1.6 Kelvin. It was what, it was the temperature. And in the early 1980s, I thought for a while that maybe I had a way to detect low-energy neutrinos using coherent scattering and helium inside and superfluid helium in the superfluid helium three phase. Well, why didn't it work?
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And it was actually a very traumatic thing, because at the time, if you could detect that, you could detect nuclear reactors anywhere in the ocean from orbit. And this was in the middle of the Cold War, and it wasn't obvious what you do with the knowledge that there was a physical way to find out where all the nuclear submarines were. It was one of those times where I was actually quite glad that the science didn't work so I didn't have to deal with the problem of what do you do with that kind of information? But yeah, you know, I think neutrinos are, you know, they have all the properties of particles, like photons and so on. They just had a slightly different interaction. And the properties of the interaction. Well, actually. Okay. Interesting fact, when I was a kid, I was about 16 years old, one of my first people that I never published was about the neutrino background radiation and it was about the possibility of a high density of neutrino background radiation because neutrinos, unlike photons, if you pack enough of them
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neutrinos have an exclusion principle because they are fermions that were half-mass, they have half-spin and so if you try to pack too many energetic neutrinos and they create a kind of thing like electrons in an atom, there can only be a certain number of neutrinos in those states. ?? So you end up with this kind of charged collection of neutrinos in the universe. And so I was wondering how you could have found that out and if it happened? You're absolutely right. They have a huge gravitational effect. Who?, neutrinos? Ha-ha So then I can another little thing that led to my favorite nuclear isotope. So back then it was way before the web, way before Wolfram Alpha, way before all those kinds of things. I wanted to find out what? Well, in nuclear

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(14)- decay, when there's beta decay, it produces neutrinos. And if you have this sea of neutrinos all filled up, the beta decay can't happen because you can't have a neutrino that that, that pokes its way into that C and so the beta decay gets that gets cut off.
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And so my question was, what is the the beta decay which has the smallest energy difference. So it has the kind of lowest energy, the neutrinos that will be most likely to sort of fall into this neutrino sea. And so that that caused me I still remember it actually leafing through every page of the table of isotopes, trying to find the beta a matter with the smallest Q value, the smallest energy difference, and the answer at least in those days, was rhenium 187. Rhenium 187 became my favorite isotope it's something which has tiny Q value. And so it, it is

sensitive to the presence of degenerate neutrinos in the universe. But but I don't think that, I mean, I think the story of, of neutrinos, I don't think that's a, so far as I know, that's not a plausible hypothesis for, Well, their, their masses are insufficient to make the closure density, you know, equal to omega matter that we observe. But. So that's, that's true. But they, but they do fulfill in other words a lot of people who say well we,
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we need Mond or we need modified Newtonian dynamics, we need some, relativistic version thereof. I mean, it's not just one type of particle, right? I mean, we have 114 elements in the periodic table. There's not just one form of matter, right? I'm saying is that if you could, identify the dark matter as this space time heat, which, you know, we can we can discuss, it would also simultaneously have to, you know, interact with or explain how neutrinos do behave, as, you know, as you say, fermions, but they have mass, but they also do not interact with ordinary matter, as does, you know, hypothesized WIMPs. is, in our models, kind of particles like electrons, neutrinos, and so on, they are kind of topological, topologically stable objects moving sort of without change through this hypergraph, without much change through the hypergraph. It's like kind of an eddy in water. The eddy can move without change.
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It can keep swirling as it as it moves. It's the same kind of thing, I think, with electrons and neutrinos and all things where you can talk about them as being identifiable particles, where the particle moves without change through space and time. It's a different thing. If you have something which is associated with the structure of space. So it would be like saying, oh, we've got, let's say what we're dealing with with, let's say sound waves. Okay. We've got sound waves and air and sound waves, this definite kind of big effect and, you know, moving through air compression, rarefaction and so on, moving through our then we have the underlying molecules just bouncing around, doing that thing at a certain temperature with a certain kinetic energy and so on. So I think the analogy it's not quite perfect analogy, but roughly the analogy is things that are identifiable particles. Well, we can pick it up and we can say this thing moves without change through space. Those are kind of like the sound waves
1:12:05
and what we're talking about in space time heat is really much like the heat that we see in for example, a gas where it really is the individual microscopic motion of molecules. So it's really a lower level object. It's a lower level construct. Now. Interesting question whether modified Newtonian dynamics has any relation to this. That is a hot topic. And if people are watching this, who are physicists who are interested in this, please contact us where we're real thing. We want to know the challenges this we have, I think a very good candidate for what the machine code of the universe is. But going from that machine code to observable features of what you can look at with your telescope or whatever, that's a lot of physics work, and it needs an army of physicists to do it. That's why I. I reached out to you to to try to solicit and elicit information and interest from my students, your students

Paradigm shifts in science and technology

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and people that want to interact with us. But, you know, we're we're running a little low on time, Steven. So we're going to have to do a part, a part two about just this work alone. And I also want to, you know, just encourage my, colleagues and so forth to, to consider, take seriously, these predictions because these are some of the, you know, foundation issues. Sometimes I feel like, Steven, you don't get the attention, you know, that that you're, you

know, deserving because you're, you're you're sort of solving so many things at once. There's there's sort of a, a bandwidth limitation, on the receiving end that that's just a natural, you

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(14)- decay, when you have beta decay, it produces neutrinos. And if you have this sea of neutrinos filled up, beta decay can't happen because you can't have a neutrino that makes its way into that C, and so the beta decay is interrupted. ?? That's stew.
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So my question was, what is the beta decay that has the smallest energy difference. So it has the lowest energy, the neutrinos that are most likely to fall into this neutrino sea. And that caused me, **that I still remember**, to actually flip through every page of the isotope table and try to find the beta matter decay with the smallest Q value, the smallest energy difference, and the answer at least at that time it was rhenium 187. I wouldn't memorize that... Rhenium 187 became my favorite isotope, it's something that has a tiny Q value. And so it's sensitive to the presence of degenerate neutrinos in the universe. But I don't think, I think, I think the neutrino story, I don't think that's, as far as I know, it's not a plausible hypothesis for,this stuttering is getting me up…. Well, their, their masses are insufficient for the confinement density, you know, to be equal to the omega mass that we observe. But. So that's, that's true. this stuttering is getting me up… But they, but they fill in with other words a lot of people who say well we,
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need Mond MOND or we need modified Newtonian dynamics, we need some relativistic version of it. It's not just one type of particle, is it? We have 114 elements in the periodic table. There's not just one form of matter, is it? What is "one form"??... I'm saying that **if** you could identify dark matter as this space-time heat that, you know, we can discuss, it would have to **it** also at the same time, you know, interact or explain how neutrinos behave, like, you know, as you say, fermions, but they have mass, but they also do not interact with ordinary matter, like, you know, the supposed WIMPs do. There is in our models a kind of particles, like **electrons, neutrinos** and so on, they are some kind of topological, topologically stable objects. O.K., according to my findings of "converting" all elementary particles "to two-character formulas", so neutrino (electron neutrino) came out to me as, like !! pure time dimension itself, apparently into some kind of topological packing, i.e. package on the time dimension. It's strange, it will be funny for our readers, it will outrage the furious, but it fits into my system of building "formulas" for elementary particles → https://www.hypothesis-of-universe.com/index.php?nav=ea ; https://www.hypothesis-of-universe.com/docs/ea/ea_002.pdf ; https://www.hypothesis-of-universe.com/docs/ea/ea_016.pdf --> leptons p. 8 ; https://www.hypothesis-of-universe.com/docs/ea/ea_024.jpg --> and here is beta decay with electron neutrino as only "from the time dimension"...; https://www.hypothesis-of-universe.com/docs/ea/ea_018.pdf and further and further through the cross-section of my entire work you will find electron neutrino as dimension "t" and...and in two-character equations it fits... now I saw this while browsing in my archive https://www.hypothesis-of-universe.com/docs/ee/ee_006.jpg ; https://www.hypothesis-of-universe.com/index.php?nav=ee ; https://www.hypothesis-of-universe.com/docs/ee/ee_049.jpg ... Everywhere there is an electron neutrino as a “t”- time dimension…; that is why the ve el.neutrino passes through the globe like a knife through butter, because it is a “tiny knot” on the time dimension…maybe it is not even a knot, but a “condensation” made from the time dimension itself, moving somehow unchanged through

this hypergraph, without major changes through the hypergraph. It is like a whirlpool in water. A vortex can move without changing.

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While moving, it can constantly swirl. It's the same kind of thing, I think, with electrons and neutrinos, these two particles are really forever unchangeable and unbreakable in interactions, neither changeable into other particles nor into "jets"... and all the things that you can talk about as identifiable particles, where the particle moves through space and time without change. That's something else. If you have something that's connected to the structure of space. So it would be like saying, oh, we have, let's say, what we're dealing with, let's say sound waves. Okay. We have sound waves and air and sound waves, this certain kind of big effect and, you know, movement through air compression, rarefaction and so on, movement through our then we have the basic molecules that are just bouncing around, doing this thing at a certain temperature with a certain kinetic energy and so on. So I think the analogy is not a perfect analogy, but roughly the analogy is things that are identifiable particles. Well, we can pick it up and we can say that this **thing** neutrino = knot on the time dimension is moving through space without change. They're kind of like sound waves

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and what we're talking about in spacetime heat is really very similar to the heat that we see in, for example, a gas, where it's really individual microscopic movements of molecules. So it's really a lower-level object. It's a lower-level construct. Now. Interesting question, is this related to modified Newtonian dynamics. That's a hot topic. And if there are people who are following this who are physicists who are interested in this, please contact us where we are real. We want to know the challenges that lie ahead, you don't want to know anything, especially not from amateur laymen, because you don't read my HDV, in the 15 years that HDV has been on the internet, about 2-3 physicists with degrees and about 15 ordinary physicists have read it and peeked into it, and that's it. (although I've reached out to thousands of physicists..., no one has an opinion, a counter-opinion and interest in the new model) I think it's a very good candidate for what the machine code of the universe is. But to move from this machine code to the observable features of what you can look at with your telescope or whatever, that's a lot of physical work and that requires an army of physicists. No. An army of astronomers does. Physicists just need a desk and a pen + the internet, and some very curious and tenacious ones even have a laboratory. That's why I turned to you to try to get and get information and interest from my students, your students. Paradigm Shifts in Science and Technology

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and people who want to communicate with us. I have been patiently writing for 25 years to "all the physicists in the world" and everyone (there were tens of thousands of them, I have proof) whom I asked to read has either not responded or refused. I know this, I have proof of it. But you know, we're a little running out of time, Steven. And not just the YouTube time, but the time that Mr. Wolfram was supposed to explain "what (it) is time". He didn't.So we're going to have to do a part, a second part about this work itself. And I also want to, you know, just encourage my colleagues and so on to consider, to take these predictions seriously, because these are some, you know, fundamental problems. Sometimes I feel, Steven, that you're **not getting attention,** Well, Steven has let me down here…(!), I'm not going to pay any more attention to him…; I didn't get the attention of physicists with my HDV either... I'm just not sure if it's for the same reason that Mr. Steven Wolfram has... erm-erm... you know you deserve it because you are, you are, you are dealing with so many things at once. There is a certain bandwidth limitation on the receiving end that is just natural,

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(15)- know, consequence. We're all absorbed in our own research, and there's very little time to pay attention to. Well, now we have, origin of time, explanation of the second law of thermodynamics, predictions of what dark matter is. It's it's as to say, overwhelming. But that doesn't mean that it's it's in any way detracting from it. But I do want to point out. Yeah, got. You know, I've been lucky enough to kind of be involved in sort of changes of paradigm. And when you change the paradigm, lots of stuff can come out. in science kind of the biggest kind of paradigm change that sort of already happened was something that I was much involved in initiating in the in the early 1980s, which is model things in nature with programs, not with equations. And so for 300 years, there was kind of this tradition that, you know, you want to make a model in science. That's an exact model. Write down a mathematical equation. People don't do that anymore. In most areas of science, people are writing down sort of rules and programs and using that as their underlying model. And that's the transformation that's taken basically 40 years to happen. And it's kind of interesting to me because I knew this was going to happen. This was, but it's very silent because it just, you know, it slowly happens. Then people take it for granted. I mean, for example, this phenomenon of computational irreducibility, I kind of, discovered that in 1984. So, so 40 years ago. And to many people, it's like, oh my gosh, this is a this is a crazy thing. How can this possibly be right?
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But what's really nice for me to see is among young scientists, many of them, it's obvious the world couldn't be any different way. And it's kind of fun to see this transition from what seems impossible to what becomes obvious. the thing that you see in, in what's happened in our physics project and so on, it's really a remarkable thing that I didn't see coming, I didn't think was going to happen in my lifetime. It's it's something where, you know, we had this burst of activity in physics roughly 100 years ago with a bunch of methodology that was both kind of the the almost philosophical methodology of kind of reasoning about relativity, about photons, things like that, together with kind of the mathematics that was developed in the, in the 19th century with differential geometry and things of this kind being able to sort of merge with that and things like matrices and so on, merging with that and giving us this moment
1:16:03
when we could really make paradigmatic progress in physics, we finally have another such moment. And the sort of the underlying paradigm is all things about computation and about these phenomena of computation. And those are very alien. Those have been very alien to people who have been sort of steeped in traditional physics. Now, I have to say, the good news in recent times has been both that a lot of different approaches in mathematical physics seem to plug in very beautifully with the kind of computational infrastructure that we have, point one and point two, through things like quantum information and so on. People who think about physics have become much more familiar with kind of computational ideas. And so it's a lot less alien to think of physics as a fundamentally computational phenomenon. But yes, it's a it's a thing where, you know, I think the, kind of well, I was saying when we started doing the physics project, five years ago. So now it's such a short time is some, you know,
1:17:05
I was saying this won't have applications for 200 years. I was wrong. There are a bunch of applications now that make use of the fact that there are other areas biology, distributed

computing, mathematics, and so on, which can use the formalism of the physics project to say things about their fields, but use the achievements of physics and the fact that it's sort of the same a formalism to import ideas from physics, you know, black holes and matter, mathematics or things about computational irreducibility and biological evolution and so on. It is a feature of the history of science that when there are new paradigms, there is low hanging fruit to be picked, and there's a lot of low hanging fruit to be picked and a lot of different areas. I mean, I'm, I'm sort of sorry that we didn't have a chance to talk in more detail about, what you can observe in the cosmic microwave background. Hey there. I know you're enjoying this episode and I just want one thing from you which is to subscribe or follow the podcast,
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whether on YouTube or on audio channels. I know you love it. I know you don't want to miss the next great episode. We have phenomenal broadcast coming up with beyond, including the

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(15)- know, consequence. We're all so caught up in our own research and there's very little time to pay attention to. Well, now we have the origin of time, the explanation of the second law of thermodynamics, the predictions of what dark matter is. It's, as they say, mind-boggling. But that doesn't take away from it. But I want to point out. Yeah, I have. You know, I've been fortunate enough to be involved in certain paradigm shifts. And when you change a paradigm, a lot of things can come out. The biggest paradigm shift in science that's ever happened was something I was very involved in initiating in the early 1980s, which is modeling things in nature with programs, not equations. And so for 300 years there's been this tradition that, you know, you want to make a model in science. That's an exact model. Write a mathematical equation. People don't do that anymore. In most areas of science, people write down certain rules and programs and use that as their basic model. That's nice... And that's the transformation that took basically 40 years. And it's quite interesting to me because I knew it would happen. It was, but it's very quiet because it just, you know, happens slowly. People then take it for granted. I mean, for example, this phenomenon of computational irreducibility, and computational irreducibility is no longer an equation? Is it a "program"?, is it a "program and rules"?, and a model, and not an equation?, **I kind of discovered it in 1984. So 40 years ago**. Congratulations on that. I discovered HDV in 1981. Then, by myself and by myself and by myself as a self-taught person, I compiled and created and modeled it, I mean the part of HDV = converting the current writing technique to another two-**character** technique. https://www.hypothesis-of-universe.com/docs/aa/aa_404.pdf . (!) Physical "valid" writing techniques using letters of the entire alphabet, the entire Cyrillic alphabet, the entire Latin alphabet and various newly invented characters, such as integral, matrix, square root, d'Alambert sign and others, all of this is replaced in HDV by using only "x" and "t". https://www.hypothesis-of-universe.com/index.php?nav=ea ; https://www.hypothesis-of-universe.com/docs/eb/eb_002.pdf ; https://www.hypothesis-of-universe.com/index.php?nav=eb . ***In itself, this implementation is an amazing model even if the two letters did not mean physical real quantities at all, let alone their dimensions.*** In 1983, I visited prof. Horský at the Faculty of Science to tell him my idea and I asked him for help and cooperation (he gave me 15 minutes in his office) and when we said goodbye on the grand staircase, he said to me a memorable sentence: "***Mr. Navrátil, physics is not going in this direction, but when you solve it, come here***". I was still polite at that time and so I did

not tell him my reaction that was on the tip of my tongue: ***"Professor, when I solve it, I don't have to come to you anymore, I'll be in the reading books."*** I don't even know if Prof. Horský is still alive.
And for a lot of people, it's like, oh my God, this is crazy stuff. How can this be right?
1:15:03
But what's really cool to see for me is among young scientists, of which there are many, it's obvious that the world can't be any other way. And it's quite fun to see this transition from what seems impossible to what becomes obvious. The thing that you see in what's happened in our physics project and so on, it's a really remarkable thing that I didn't see coming, I didn't think would happen in my lifetime. It's something where, you know, we had this explosion of activity in physics about 100 years ago with a lot of methodology that was kind of this almost philosophical methodology of thinking about relativity, about photons and things like that, along with the kind of mathematics that was developed in the 19th century, merge with that and give us this moment
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when we could actually make a paradigmatic advance in physics, we finally have >another such moment<. ? And the basic paradigm is all the things about computation and these phenomena of computation. But you said a moment ago, on the contrary, that you were abandoning computation in the 1980s. (?!) And those are very foreign. Those were very foreign to people who were kind of immersed in traditional physics. Now I have to say that the good news lately has been how a lot of different approaches in mathematical physics seem to be connecting very nicely with the kind of computational infrastructure that we have, point one and point two, through things like quantum information and so on. People who think about physics have become much more familiar with the kinds of computational ideas. And so it's much less foreign to think of physics as a fundamentally computational phenomenon. But yeah, it's a thing where, you know, I think kind of well, I said when we started doing the physics project five years ago. So now it's such a short time, you know,
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I said this won't have applications in 200 years. I was wrong. Now there are a lot of applications that take advantage of the fact that there are other areas of biology, distributed computing, mathematics, and so on, that can use the formalism of the physics project to say things about their fields, but they use the achievements of physics and the fact that it's kind of the same formalism to import ideas from physics, you know, black holes and matter, mathematics and things about irreducibility and computability. It's a feature of the history of science that when there are new paradigms, well, it would be good, Mr. Wolfram, if you could list the paradigms and write a few words of explanation for each one... you have to pick the low-hanging fruit, and there's a lot of low-hanging fruit to pick, and there's a lot of different areas. I mean, I'm a little sorry we didn't get a chance to talk in more detail about what you can observe in the cosmic microwave background. Hi. I know you like this episode, and I want **just one thing** from you, and that's to subscribe or watch the podcast, you want "just" one thing??? That's not enough...
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whether on YouTube or the audio channels. I know you love it. I know you don't want to miss another great episode. We have phenomenal broadcasts coming out, including
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(16)- father of Meta's AI systems. We have conversations with Neil deGrasse Tyson, Brian Greene and many, many more coming up. It's going to be a blast. The end of 2024 is going to be lit, and so is the beginning of 25. So to me, that favor will want you. Now back to the episode. Well, yeah. I just want to leave it as sort of an exercise to the, to the viewer. But now, in seriousness, I'd love to come back and and do a second part. I mean, we already, you know, kind of deserve 4 or 5 parts, but but I know your time is very valuable, but I do want to point this out. You mentioned it, and I say this with love and respect, as usual. But you mentioned dark matter, but dark matter, you know, the paradigm, as in your words suggest, is called dark matter. And it's it's sterile neutrinos. It's it's, axion things that are very low temperature phenomena. Whereas whereas we have access with our telescopes, Simons Array and other telescopes to potentially this is, it's one of Galileo's, original papers.
1:19:09
I know I have that, the other room over here, but in reality, the the origin of the universe, to me suggests the the best and most fertile playground to investigate the history of the early universe computationally. And I just sketched out some ideas that I had, and I'm not even a, you know, a theoretical astrophysicist, but but the fact that, the CMB is sort of the, the it's well, it is the oldest possible light in the universe. It's the oldest possible light to heat left over from the formation, the fusion of the very first elements and and the very earliest nuclei, on the periodic table, small lightest nuclei on the periodic table. And it is intimately related. There's a direct correlation between temperature and redshift. And then given, a couple of very modest assumptions, connect redshift to time. So here we have temperature and time. And it's because it's the oldest light in the universe. It's the most pristine relic that we have. And therefore it behooves us to pick
1:20:04
that low hanging fruit that you just said. So again, leaving this for an exercise. But but I do want to come back to this in the, in the near future. And I do want to send some of my, you know.

Exploring the cosmic microwave background (CMB)

Let's do it. So yeah. Yeah. So I do want to ask you that the fundamental observable in the CMB that's been measured to extremely high precision is its temperature anisotropy spectrum. And the fundamental the largest scale and therefore the most pristine massive fossils on the microwave sky in the beach ball behind me, on my shelf over there are relics of the gravitational potential wells that were laid down in most models of cosmology by inflation. That inflation gives us an opportunity to probe even more tiny scales close to the Planck scale. And so it seemed to me to be the ideal laboratory. So. So, Stephen, let me let me just ask you a couple of things. If we were to apply this, how would we what could we expect from you? I can give you the data. I can give you spectrum.
1:21:02
I can give you correlation functions. I can give you, power spectra. Can you predict the temperature anisotropy spectrum on this beach ball? Can you does it emerge given a modest amount of assumptions? Could we get a prediction of that? And then eventually we'll need to get the polarization, because only by getting the polarization can we see the tensor perturbations thought to be harbingers of inflation. So first can you predict the temperature spectrum. yet. I that's that's a hard ask. I mean, it's it's like asking, you know, it's like given. You know what we know about quarks and gluons. Tell me about the the fission of a uranium nucleus. there's a a depth of computational irreducible. Say, we can be lucky and find certain kind of paths through that. Now, having said that, I can tell you what some of the steps are.

what we really want to find first is an analog of the Friedman, Roberts and Walker metric. That is the, you know, the homogeneous universe metric that describes an expanding universe.
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But the usual such metric, the, you know, defines such a universe with only one parameter, which is radius, its effective radius, so to speak. We need another parameter, which is its effective dimension. We need a version of that that has dimension change. So that's if we can get that. First we get for the homogeneous case. Then we look at inhomogeneities in dimension. And the most exciting thing there is the possibility of dimension fluctuations left over from the early universe. And the question then is what is the effect of a dimension fluctuation on the CMB? And that to me is is the most likely kind of very bizarre thing that we'll see. Okay. And I don't know you know, when you ask, there are photons. So so how do

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(16)- the father of Meta AI systems. We have interviews with Neil deGrasse Tyson, Brian Greene, and many, many more that are coming up. And nobody has read HDV. It's going to be a blast. It's going to light up the end of 2024 and the beginning of '25. So I think the favor will be yours. Now back to the episode. Okay. I want to leave it as a kind of exercise for the viewer. But seriously, I'd like to go back and do a second part. About "what is time," right? I think we deserve 4 or 5 parts, but I know your time is very valuable, but I want to point this out. You mentioned it, and I say it with love and respect, as usual. But you mentioned dark matter, but dark matter, you know, the paradigm, as your words suggest, is called dark matter. And they're sterile neutrinos. Whether they make neutrino mass in a black hole, I can't say, but what I do know about fusion, why physicists will never succeed, is that there are flaws in the theory, not least in the "uncertainty" theory. That's where the "time" is missing. There's "a lot of time" built into the Sun, a lot of tangled, crumpled time dimensions, and maybe even neutrinos. These are axion things, which are very low-temperature phenomena. While with our Simons Array and other telescopes we have access to this potentially, this is one of Galileo's original documents.
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I know I have the other room, but the origin of the universe actually presents me with the best and most fertile playground for calculating the history of the early universe. And I just sketched out some ideas, where? I'd love to read them... that I had, and I'm not even, you know, a theoretical astrophysicist, but the fact that the CMB is something like, like? What? that's good, it's the oldest possible light in the universe. It's the oldest possible heat left over from the formation, the fusion of the very first elements and the earliest nuclei in the periodic table, the small lightest nuclei in the periodic table. And that together is closely related. Together with what? There is a **direct** connection between temperature and redshift. Are you so sure? For example, with Hubble's law, it's not that true. Linearity $\boxed{\mathbf{v = H_0 . d}}$ is only valid up to a certain distance towards the Big Bang, https://www.hypothesis-of-universe.com/docs/c/c_239.jpg then the linearity changes and…and thus the observed/measured values that surprise physicists, see the Webb telescope. And then assuming a few very modest assumptions, connect redshift with time. So here we have temperature and time. No, first redshift versus time. And that's because it's the oldest light in the universe. It's the most original relic we have. And that's why it's up to us to choose.
1:20:04

the low-hanging fruit you just said. So again, leave that for an exercise. But I want to come back to it in the near future. And I want to send some of mine, you know. Exploring the cosmic microwave background (CMB). Let's do it So yeah. Yeah. Maybe Wolfram will finally say "what is time" (according to him). So I want to ask you, the fundamental observable in the CMB that has been measured with extremely high precision is its temperature anisotropic spectrum. And the fundamental largest scale, and therefore the most original massive fossils in the microwave sky in the beach ball behind me, on my shelf, are the remnants of the gravitational potential wells that were created in most models of inflationary cosmology. Post-Bang spacetime, curved into foam, "unfolds" (not expands) "with time" https://www.hypothesis-of-universe.com/docs/c/c_032.gif ; and this unrolling of dimensions >simply< goes through a phase when a "parabola" rules…, that is the essence of gravity = parabolic curvature of 3+3 spacetime. Some geometric curvatures have been preserved since the CMB, others not. This inflation (which I don't believe in) gives us the opportunity to explore even smaller scales close to the Planck scale. And so it seemed like an ideal laboratory to me. So. So, Stephen, let me ask you a few things. If we were to apply this, how would we, what could we expect from you? I can give you data. I can give you a spectrum.

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I can give you correlation functions. I can give you, energy spectra. Can you predict the temperature anisotropy spectrum on this beach ball? Can you show up with a modest amount of assumptions? Could we predict it? And then eventually we will need to get polarization, because only by getting polariz. Yes, the unrolling of the foam of dimensions after the big bang is not an isotropic fact, it is "more diverse", polarization of states of curvature of dimensions arises. How, why, I don't know… I only know that the same thing as after the big bang is happening today on Planck scales where the "vacuum boils" there is foam of dimensions and it unrolls into a soup of plasma, non-isotropic and packets of elementary particles are created. It is similar to what happened in the CMB. When we send Webb Telescope No. 2 into the microcosm, maybe we'll be able to tell the difference between the "foam" on Planck scales and the "boiling vacuum" of the CMB. So first you can predict the temperature spectrum. Again. That's a tough question. I mean, it's like asking, you know, it's like a given. You know, what we know about quartz and gluons. Tell me about uranium fission. There's a depth of computational irreducibility. I only half understand this... Let's say we can get lucky and find some kind of way through it. Now that I've said that, I can tell you what some of the steps are. What we really want to find first is an analogy to the Friedman, Roberts, and Walker metric O.K. That's, you know, the metric of the homogeneous universe, O.K. which describes the expanding universe.

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But the usual metric, you know, defines such a universe by only one parameter, O.K. which is the radius, its effective radius, so to speak. We need another parameter, which is its effective dimension.?? What exactly is that? We need a version that has a change in dimensions. What? By curvature, or this one you said you were looking at 2.9 pieces of dimensions…? That is, if we can do it. First, we'll get to the homogeneous case. Then we'll look at inhomogeneities in the dimension. Aha…ha. And the most exciting thing is the possibility of dimensional fluctuations left over from the early universe. So I don't get this vision. What is this "dimensional fluctuation"? You should distinguish **dimension from dimension**. https://www.hypothesis-of-universe.com/docs/c/c_278.jpg ; https://www.hypothesis-of-universe.com/docs/c/c_041.jpg And the question then is, what is the effect of the dimensionality fluctuation on the CMB? And that to me is the most likely kind of very bizarre thing that we're going to see. Okay. And I don't know, you know, if you ask, there are photons. So how do you do that?

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(17)- photons propagate if we have a plain wave of photons. So we have, we have just, sort of a source an infinite distance away. And what was a circle? We've now just seen a, you know, a single piece of it that's a plane wave.
1:23:02
Well, a way to think about that plane wave is it's made up of a large number of little spherical wavelets. At every point on the plane wave, it makes a new plane wave by having these little spherical pieces on the first plane wave. And so I think there's a way to think about that when you have a dimension fluctuation, those little spherical wavelets become hyper spherical wavelets, and the structure of the plane wave is changed. And so but exactly how we don't know. My guess would be that it is, if you propagate a plane wave through a dimension fluctuation, you will get something, which is a weird form of gravitational lensing. My guess is that it will shatter the plane wave, basically, whereas gravitational lensing, just concentrates it, just focuses it. My guess is that dimension fluctuations will essentially shatter that plane wave. Giving it like a caustic, a caustic sort of behavior.
1:24:00
Right. Intensified. I. Yeah. a, an electromagnetic wave propagates through a region that has variable dimension. What happens in the other universe when dimension is a dynamical parameter where you have, oh, there's this region of space that has dimension 3.01, there's this neighboring one that has dimension 2.98. And how does that how does that, you know, when you when you start off in the early universe with, let's say infinite dimensional, infinite dimensional space, and you end up with something that's sort of cooling down to this lower dimensional space, what kind of spectrum of fluctuations gets left over? We don't know. But that's something that is is within the realm. I mean, okay, here's here's the foundational problem there. The mathematics you need is completely unknown. And we're trying to build it. But here's how it works. So, you know, if you study calculus, you'll study univariate calculus, calculus of one variable.
1:25:03
You'll study multivariate calculus, calculus where there's variables x, y, z, and so on. What we need is calculus whether a fractional number of variables. And nobody's ever figured that out. and that's simply a mathematical structure that hasn't been built with. We're in the process of building it, but it's a fairly heavy lift. I mean, that's a that's a deep, foundational piece of mathematics that has to be built to be able to, you know, have a place where we can really talk about things like propagation of electromagnetic waves and fractional dimensional space and so on. But so if you were to, you know, if I were to guess what the kind of thing that you will see will be something that is very bizarre that you never expected. It's not something where, you know, my experience. Spherical harmonics.
1:26:03
Right. doing for, for, well, 45 years now is just doing experiments in the computational universe. You set up these rules, you see what they do. The thing that is really shocking is pretty much every week when I'm working on this kind of thing, there'll be something when I say, I know what this is going to do. I've been doing this for 45 years. I know what this is

going to do, and it does something bizarre and unexpected. and that's a piece of intuition one doesn't usually have. One usually thinks once you kind of sort of know what this general kind of thing, how this general kind of thing works, you kind of know what's going to happen. What one sees in these computational systems is bizarre phenomena that one never expected, like dimension fluctuations, are an example of something that, you know, if you just live in standard general relativity, you would never imagine a phenomenon like dimension fluctuations. So I think that the you know, the thing is,
1:27:03
you know, this is a sort of, you know, when you make measurements, you know, I would say my one sort of piece of experimental advice, so to speak, is keep all the data. By which I mean, if you're using, you know, the analog of sort of software, radio to collect things and you're and you're kind of, you know, picking out, you're doing Fourier analysis of it to pick out a particular frequency spectrum and things like this. Keep all the data. Don't just keep the thing. That was the results of the Fourier analysis. Keep the Well, that's a massive. That's a massive challenge. And we are. We are doing that at the Simons Observatory. Will get of order a terabyte of data every day from four telescope sampling, 100,000 detectors 100 times per second in two different polarization states and six frequency bands. We just started to get first light, data. Just a few months ago. Jim Simons got to see it before he passed away. But,

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(17)- photons propagate if we have an ordinary wave of photons. So we have, we just have, some kind of source infinitely far away. um, And what was that circle? We just saw, you know, the only piece of it, which is a plane wave.
1:23:02
Well, the way to think about that plane wave is that it's made up of a lot of little spherical wavelets. At every point of the plane wave, it creates a new plane wave by having these little spherical pieces on top of the first plane wave. And so I think there's a way to think about that when you have dimensional fluctuation, ?? 3+3D spacetime can't have dimensional fluctuation?…what do you mean? The extra dimensions are "mathematical dimensions," not physical ones. these little spherical wavelets become hyperspherical wavelets, and the structure of the plane wave changes. And so, but how exactly, we don't know. Me neither, but I know that the "packages=knots" on the dimension shift = roll over, https://www.hypothesis-of-universe.com/docs/c/c_275.gif (imagine the image in your vision as if it were a 3+3D image), which creates that anisotropy "on the cross section". I guess so, if you propagate a plane wave by varying the dimensions, the dimensions do not vary, the curvature of the dimensions varies... you get something, which is a special form of gravitational lens. It can also be explained by "variation of the curvature of the dimensions"... My guess is that it basically breaks the plane wave, while the gravitational lens only focuses it, only focuses it. No. My guess is that the fluctuation of the dimensions basically breaks the plane wave. No. Putting it like a caustic, a caustic kind of behavior.
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Right. Amplified. Me. Yeah, and, an electromagnetic wave propagates through a region that has variable dimension. No, it has variable curvature of dimensions… What happens in another universe when dimension is a dynamical parameter, where you have, oh, there's this region of space that has dimension 3.01, there's an adjacent region that has dimension 2.98. A…a…aha, uuuu, it's clear to me where / where your reasoning is leading: you are changing the "number of dimensions" to non-integer numbers, well, that's nonsense. The universe,

space-time, is ruled by the curvatures of integer 3+3 dimensions … And how do you do that, you know, if you start in the early universe with, let's say, infinitely dimensional, infinitely dimensional space and you end up with something that cools down a little bit into this lower dimensional space, what spectrum of fluctuations are you left with? We don't know. But that's something that's in the realm. I mean, okay, here's the basic problem. Here? The math you need is completely unknown. It's known, it's HDV, which "packs" dimensions into simple formulas… https://www.hypothesis-of-universe.com/docs/c/c_275.gif ; https://www.hypothesis-of-universe.com/index.php?nav=ea ; we just don't know the curvatures… And we're trying to build it. No, you're not trying to read other visions. But here's how it works. Oooh, I'm curious…where? So you know, when you study **number**, dimensions = dimensions you're studying one-dimensional number, one-variable number.

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You will study multidimensional calculus, calculus where the variables are x, y, z and so on. https://www.hypothesis-of-universe.com/docs/c/c_043.jpg ; general formula for packing 3+3 dimensions. What we need is a number, not just a number, (***3+3D physical, and n+m mathematical dimensions***), but the curvature of the dimensions… or a fractional number of variables. **And…aaaah, oh god, I'm sorry. (Senior dementia is setting in). I know "what" you mean. Yes. Fractional dimensions are also applied in HDV for quarks, they are no longer used elsewhere**, https://www.hypothesis-of-universe.com/docs/ea/ea_002.pdf and maybe also for gluons → https://www.hypothesis-of-universe.com/docs/ea/ea_026.jpg ; Only when the plasma expands more, will the "fractional quarks" combine so that the construction of other elementary particles from **integer dimensions" prevail.** ! So "fractional dimensions" only in the pre-relic period.

And nobody ever figured it out. I did, 40 years ago, and that's just a mathematical structure that hasn't been built. HDV - - That's proof that physics majors don't read my HDV model. We're working on building it, but it's a pretty heavy lift. ☹ I mean, that's a deep, fundamental piece of mathematics that has to be built in order to, you know, have a place where we can actually talk about things like electromagnetic wave propagation and fractional dimensional space I mean no, that's only in matter and so on. But if you had to, you know, if I had to guess what kind of thing you're going to see, it's going to be something very bizarre that you never expected. It's not something that, you know, my experience. Spherical harmonics.

1:26:03

Right. Doing for, for, well, now 45 years is just experimenting in the computational universe. When you set these rules, you see what they do. The thing that's really shocking is basically every week when I work on this kind of thing, there's something that I'll say, I know what this will do. I've been doing this for 45 years. I know what this will do, and it will do something bizarre and unexpected. And that's a piece of intuition that you don't usually have. You usually think that once you kind of know what a general thing like this, how a general thing like this works, you kind of know what's going to happen. What you see in these computing systems are bizarre phenomena that you never expected, like dimensional fluctuations, they're examples of something that, you know, if you live in standard general relativity, you would never imagine a phenomenon like dimensional fluctuations. Abstraction or reality? So I think you know, the thing is,

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you know, this is kind of, you know, when you're doing measurements, you know, I would say, the stuttering is awful. That my one kind of experimental advice, so to speak, is to keep all the data. I mean, if you're using, you know, analog kind of software, radio to collect things, and you kind of, you know, select, do a Fourier analysis to select a particular frequency spectrum and things like that. Keep all the data. Don't just keep that thing. Those were the Fourier analysis results. Keep the Well, that's massive. That's a huge challenge. And we are. We're doing it at Simons Observatory. Every day it gets a terabyte of data from four telescope samples, 100,000 detectors 100 times a second in two different polarization states and six frequency bands. No fragmentation, right? We just started getting the first light, the data. A few months ago. Jim Simons must have seen it before he died. But,

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(18)- yeah, Stephen, this has been so fascinating. I it's always, you know, parting is such tweets. But but, you know, the time has come around here in the Keating to,
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to put the Keating kids to bed. but before I go, I want to read you a quote. And it's, 1700 years old from Saint Augustine. He said, what is time if no one asks me? I know, but if I try to explain it, I cannot. And he discovered something very interesting as he finally mused at the end of his essays, he said, what we measure not is not. It's very evocative to me of what you're doing, because in a large sense, as you as you conclude, you know, this principle of computational equivalence allows, there to be a robust notion of time independent of the substrate that's involved, whether it's us as observers, the everyday physical world, or for that matter, the whole universe. I think Saint Augustine would be quite pleased to see what you're doing. You could have allayed a lot of his questions, Stephen. And I do hope I'm going to send, my undergraduates this this, essay.
1:29:01
And we have been doing some stuff quite unsuccessfully, unfortunately. We tried to ask a quick question. What would a, we had ChatGPT if we had the, Mathematica in the year, let's let's call it an 1877. And we had all of Mercury's orbits, for the previous year, tens of thousands of years. Could a computational system have derived the laws of what we call general relativity? And it turns out we can't. We we know for sure we can't do it with LMS. We can't effectively do it with this. Right? No, no. But we use some of your symbolic regression, techniques. And we basically have to insert by hand. the curvature of space. We make these graviton magnetic effects. I'll, I'll bring that up to you sometime, and maybe you can. Yeah. in the version of Wolfram Language which will come out in, beginning of next year. We can actually compute the, the advance of the perihelion and Mercury. It's kind of cool. We have enough. Enough, capability and, astro dynamics
1:30:05
and so on to be able to do that. It is if you if you didn't believe in relativity before, after you've dealt with all these crazy coordinate systems in the solar system and all of that different time bases and so on, you have no choice but to to really, you know, field relativity, so to speak. But I don't think, I think this idea of going from the what we see in the world to deduce its underlying laws, that's a whole nother discussion. But that's a that's that's all of these ideas about computational irreducibility and so on kind of say that doesn't really work. That doesn't that doesn't really it's not really the thing. that's a whole nother story. But I but I liked your, your quote from Saint Augustine. Yeah. See? It'd be. able to start talking about from some of

these things, from the physics project, the really odd things like this are foundational questions in science
1:31:03
that actually predate modern science. People like, you know, the the theologians of a thousand years ago, whatever. Had things to say about these, these questions and what they said was often quite interesting. And it got kind of swept away by the advance of mathematical science. it's really kind of dramatic that at this point, we're able to kind of dig deep enough that we can get back to some of those foundational questions as what we should, you know, because these are the most basic

Outro

questions and they'll be started off. What is life. What is consciousness. What is time. It seems to me you're addressing all three of these, questions. And I couldn't be more excited, for what you get for fun. Now. I only know the direction to go for the answer to the what is life question. But we'll get there. It'll get there. It's time. Well, thank. Thank you so much. We'll be in touch and we'll do it again, hopefully very soon. Thank you. Hey there.
1:32:00
I know if you're listening to this podcast, you're going to love this conversation with Stephen Wolfram from earlier
1:32:05
this year, where he claims to have solved the second law of thermodynamics. Click here for that, and don't forget to subscribe.

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(18)- Yes, Stephen, it was so fascinating. I always, you know, breakups are tweets like that. But, you know, here in Keating, it's time to
1:28:06
put the Keating kids to bed. But before I go, I want to read you a quote. And it's 1,700 years old from Saint Augustine. He said, what time is it when no one asks me? I know, but when I try to explain it, I can't. And I discovered something very interesting when he finally reflected at the end of his essays, he said that what we don't measure is not. It's very evocative of what you're doing, because in a big sense, how you draw the conclusion from that, you know, this principle of computational equivalence allows for a robust notion of time independent of the substrate that's involved, whether it's us as observers, the everyday physical world, or actually the entire universe. I think Saint Augustine would be quite happy to see what you're doing. You could have dispelled a lot of his questions, Stephen. And I hope to send this essay to my undergraduates.
1:29:01

And unfortunately, we've been doing some things that we've been doing quite unsuccessfully. We tried to ask a quick question. What would it be, we had ChatGPT, if we had Mathematica in the year, let's say 1877. And we had all the orbits of Mercury for the previous year, tens of thousands of years. Could a computational system derive the laws of what we call general relativity? And it turns out we can't. We know for sure that with LMS? we can't. We can't do it efficiently. Right? No, no. But we use some of your symbolic regressions, techniques. And we have to input essentially by hand. The curvature of space. We create these graviton magnetic effects. I'll do it, I'll bring it to you sometime and maybe you can do it. Yeah. In the Wolfram Language version that's coming out early next year. And there's where Wolfram explains "what is time"???? We can actually calculate the perihelion and the Mercury

advance. It's kind of cool. We have enough. Enough, the capabilities and the astrodynamics
1:30:05
and so on to be able to do that. If you didn't believe in relativity before, after you've been through all these crazy coordinate systems in the solar system and all these different time bases and so on, you have no choice but to really, you know, field relativity, **?** so to speak. But I don't think, I think this idea of taking what we see in the world and deriving its fundamental laws, that's a whole other discussion. But that's what all these ideas about computational irreducibility and so on are, it kind of doesn't really work. No, it's not really that. That's a whole other story. But I liked your quote from Saint Augustine. Yeah. See? It would be. To be able to start talking about some of these things, from a physics project, really strange things like this, are fundamental questions in science
1:31:03
that actually predate modern science. People like, you know, theologians thousands of years ago, whatever. They had something to say about these questions, and what they said was often quite interesting. And it's kind of been swept away by the progress of mathematical science. It's really a little dramatic that at this point we're able to dive deep enough to be able to come back to some of those fundamental questions, like we should, you know, because these are the most fundamental Outro questions and they're going to be launched. What is life. What is consciousness. what is time. Wolfram doesn't know! Although the title of this article, podcast is “Stephen Wolfram’s Groundbreaking New Theory “. Otherwise he would be boasting. It seems to me that you are addressing all three of these questions. And I couldn’t be more excited about what you are getting for fun. Now. I only know the direction to go in order to answer the question of what life is. But we will get there. It will get there. It is time. Okay, thank you. Thank you very much. We will be in touch and do it again, hopefully very soon. Thank you. Bye.
1:32:00
Iknow that if you listen to this podcast, you will love this interview with Stephen Wolfram, I mean no, he is not a perfectionist, he has a gibberish… from earlier
1:32:05
this year, where he claims to have solved the second law of thermodynamics. ☹ Click here and don’t forget to subscribe.

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JN, 18.03.2025, it's 22:32h (tomorrow is a holiday) + překlad 20.03.2025