Demetri Kofinas:	00:00	Today's episode of Hidden Forces is made possible by listeners like you. For more information about this week's episode or for easy access to related programming, visit our website at hiddenforces.io and subscribe to our free email list. If you listen to the show on your Apple podcast app, remember, you can give us a review. Each review helps more people find the show and join our amazing community. And with that, please enjoy this week's episode.
Demetri Kofinas:	00:48	What's up everybody? My guest today is Sean Carroll, a best-selling author and research professor of theoretical physics at the California Institute of Technology. He's written both as an author and as a researcher about fundamental questions in physics and cosmology, especially issues of dark matter, dark energy, space time symmetries, and the origin of the universe. And more recently on the foundations of quantum mechanics, the emergence of space time, and the evolution of entropy and complexity. Our focus today is on the subject of Dr. Carroll's latest book, Something Deeply Hidden: Quantum Worlds and the Emergence of Spacetime.
Demetri Kofinas:	01:34	You'll notice that we jump around quite a bit, and much of the conversation bends towards the philosophical, including ontological questions about the nature of reality, and the possible limitations of science as an epistemological tool for making definitive statements about our own conscious experience of that reality. There's a lot in this conversation to unpack. And although I've tried my best to grasp the various interpretations of quantum mechanics, the implications of the theory are so at odds with our own experience of the physical world, that it's been a continuous struggle for me to try and understand them. And I want to understand them. Or at least I want them to feel more accessible to me. And though I can't say that I've accomplished that, I think there's value in trying to engage with things that we struggle to understand.
Demetri Kofinas:	02:31	This is something that came up in our recent episode with David Epstein. When you struggle to understand something, when the learning process feels difficult, it's often a sign that you're learning and retaining that much more. So just a thought to bear in mind, in case like me, you struggle with this subject. Now, for subscribers to our overtime feed, we spend the balance of our time discussing more off-the-wall subjects. I mean, we start with the impact of quantum mechanics in culture, but we move into discussions about time travel, artificial intelligence, aliens, Flat Earth Theory, and a little bit of 1980s Sports trivia. Carroll grew up in Philadelphia during the Dr. J. Moses Malone and Charles Barkley era. So, we had a little fun with that. And now, without any further ado, here is my conversation with Dr. Sean Carroll. Dr. Sean Carroll, welcome to Hidden Forces.
Sean Carroll:	03:39	Thanks very much for having me.
Demetri Kofinas:	03:40	It's so cool having you here. I'm actually more geek than I thought I would be.
Sean Carroll:	03:45	Well, the word hidden appears in the name of my book, Something Deeply Hidden, so there's obviously an overlap here.
Demetri Kofinas:	03:50	So, when I contacted, did you see that in the podcast and say, just based on that word alone...

Sean Carroll:	03:54	[laughter] Yes, that's completely the reason why. Absolutely.
Demetri Kofinas:	03:57	No matter what this person is doing, we have something in common. I mean, I've always been interested in quantum mechanics because like everyone, it's quantum.
Sean Carroll:	04:06	Yeah. Exactly. As part of the research I did for reading my book is that I went to amazon.com, I typed in the word quantum to the search bar, and looked up all the crazy books with the word quantum in the title. Quantum yoga, quantum healing, quantum leadership, quantum touch, quantum therapy. It's an idea that is suffused into culture without anyone understanding it. So, we need to do better.
Demetri Kofinas:	04:27	Was that your lecture that brought up the quantum like survival bed?
Sean Carroll:	04:31	I don't think so.
Demetri Kofinas:	04:32	Maybe it was somebody else because someone else has done this. Maybe it was Greene. There're so many people. The other thing that's amazing about this subject, whether it be quantum mechanics, whether it be something else in physics, is that people are really interested in this stuff. Millions and millions of views each for these videos.
Sean Carroll:	04:47	No, absolutely. I think that we underserved the desire for people to have interesting, helpful, thought provoking discussions about science. We do certain things, but I think we underestimate how much we people are willing to stretch their minds a little bit to get their brains around it.
Demetri Kofinas:	05:03	I also wonder if it's also biased by the fact that people probably watch those videos over and over because they don't get it.
Sean Carroll:	05:09	I don't think so. No, I don't think so. Because there's so many other videos for you watching, right? Like, you just skip to something else. Even on TV, I've been very frustrated with things, I don't want to mention any names, but there's certain networks or rather cable channels, I should say, that have science shows, but no professional scientists are involved in the making of the science shows.
Demetri Kofinas:	05:28	Like on Gaia TV, you watch Gaia TV?
Sean Carroll:	05:30	I don't watch that one actually. But they'll be producers who go to Wikipedia and look up black holes and make a TV show based on that. And they often do a pretty good job, but it can be so much better if you actually trusted the audience.
Demetri Kofinas:	05:43	Yeah. So, the first time that I ever tried to learn anything about quantum mechanics was, because I thought about this, was in 2004, and I think it was January or February, beginning of spring semester in college. There was a book out called Quantum Gravity that year. I didn't get it. The only thing I remember-
Sean Carroll:	06:05	You didn't buy it or you didn't understand it?

Demetri Kofinas: 06:10 I bought it. And the only thing though that stuck out to me was at the very beginning of the book, where he talks about how in meeting after meeting and dinner after dinner, the one thing that is true is that they can all agree on the mathematics and none of them can agree on what it actually means in practice, or what it means to actually live in a quantum world. And I feel like that sort of is just a big part of what your book is about.

Sean Carroll: 06:32 Yeah, except we don't even agree on the mathematics. That's the thing. We agree on the beginning and the end, we disagree on what happens in between. So, if you set up a quantum mechanical system, which by the way, is every system in the world, right? I mean, we see quantum mechanics manifest itself when you look at electrons or atoms or very tiny things, but it's the fundamental way that the world works at the basic level. And we can set up a system like an atom, we can let it evolve for a little bit and then we can observe it. And we can predict with wonderful precision what the probability is of getting different measurement outcomes. Really, really good precision. Like, it's certainly right. It's certainly on the right track.

Sean Carroll: 07:09 But then if you ask, okay, what happened in between when you set up the system and when you looked at it? What does it mean to look at it? What was the interaction or the equation, the laws of physics that governed you looking at it? We don't know. We don't even know the math of there. So, it's not just that we know the math, but not the physics, we don't even know either one.

Demetri Kofinas: 07:27 We don't know the math before we observe the system?

Sean Carroll: 07:29 Yeah. If you say like, what is going on? What is the physical stuff that is changing while you're not looking at it? We don't agree. Different people have different ideas about what the answer of that is.

Demetri Kofinas: 07:39 So this is a really good time to maybe talk about the measurement problem, because this is part of the issue. But also, maybe we could start with kind of foundationally, how did this theory even developed, where did it come from?

Sean Carroll: 07:51 Right. I think that's the right way to start. So, let me give you, and not completely historically accurate, but hopefully, comprehensible answer. We've all seen the cartoon picture of the atom with like little nucleus at the center and electrons going around in what looks like orbits, right? It looks like the solar system; a little tiny solar system is what the atoms are like. So that can't be right. That was a picture that was put together in the early 20th century around 1909. Ernest Rutherford, especially. And we know it can't be right, because if electrons were orbiting atoms, the nucleus of an atom, they would be giving off radiation. They'd be giving off electromagnetic waves. And they'd be losing energy and spiraling into the middle of the nucleus. So, all of matter, like you and me and the table and the Earth would be wildly unstable and would just collapse into a point. That's clearly-

Demetri Kofinas: 08:40 Would the world be just one giant black hole?

Sean Carroll: 08:41 Basically, yes. That's right. That's the prediction unambiguously. So that's not right. So, what's going on? And it took a lot of banging your head against the wall to come up with a good theory, but the theory eventually was, electrons are not even particles. Electrons are not orbiting like little planets around the Solar System because they're actually waves, which we cleverly called the wave function of the electron. The wave function of the electron is spread out in the little cloud around the nucleus. And there's different ways the cloud can vibrate. But all of them have some heft to them, all of them have some size, they don't just collapse to the middle. So that's the answer. That was a good idea, it's the right answer.

Demetri Kofinas: 09:21 That's all derived mathematically at first, right?

Sean Carroll: 09:24 I don't know what you mean. I mean, we go back and forth between data and ideas and math. So, it was a proposal, electrons are waves. And then later Schrodinger came up with an equation. Erwin Schrodinger, the great physicist came up with the Schrodinger equation, which says, here's how wave functions evolve. Here's how they behave, what they do, how they evolve. And it's all perfect until you look at it, and that's the measurement problem that you noticed. So what Schrodinger's equation says is that an electron within this little cloud, if you remove it from the atom, if you just put it out there and empty space, that wave function, that cloud, should just spread out all across the universe.

Sean Carroll: 10:02 But when we look at electrons, we don't see clouds of wave function spread out all across the universe. We see them in a particular location as if they were a particle. And that's the weird thing. Quantum mechanics, unlike any other kind of physics seems to require that electrons or other quantum systems behave differently when we are looking at them or when we are not.

Demetri Kofinas: 10:25 Why?

Sean Carroll: 10:26 Well, no one knows. I mean, that's the measurement problem. So, we don't know what it means to measure something. We don't know, and when I say we don't know, what I mean is, according to the conventional wisdom, according to what we teach our students in business courses, we don't agree, let's put it that way. And what it means to measure something when a measurement happens, why wave functions collapse to points, any of those things.

Demetri Kofinas: 10:46 So I do want to talk about all those things in detail. And I think one place that they'll naturally come up is when we talk about Many-Worlds and some of these alternative hypotheses, but give me a further continuum of the history. Like, when did we first have the double-slit experiment? What was the initial reaction of that? What were some of the early counter arguments?

Sean Carroll: 11:02 Yeah. So, there's actually two tracks in the early 20th century. One was people like Max Planck and Albert Einstein were discovering that light, which we had agreed in the 1800s was a wave, actually had particle like properties. So, it was really Einstein more than anyone else who should get credit for initiating quantum mechanics. It was really Einstein who said in 1905, out loud, maybe light is just particles. Okay. Even though we had known, we had very good evidence it was waves. Einstein says, well, there's certain circumstances under which it really acts like particles. Meanwhile, on the political side of the ledger, people like Louis de Broglie, who was a French physicist, and Erwin Schrodinger said, maybe electrons particles are really like waves. So, we had this confluence of ideas that were saying that everything in the universe has some particle like properties and some wave like properties.

Sean Carroll: 11:55 In around 1926, 1927, we settled on this idea that the thing was that things really are waves, those are the most important fundamental things. But when we look at them, they look like particles. So that's the bizarre thing that we're trying to deal with to this day, why does looking at something have any role to play in the fundamental formulation of a physical theory. Now, the double-slit experiment we can talk about, but let me just emphasize, it wasn't done. Like, no one did the double-slit experiment to like the 70s or 80s. It was a thought experiment. Yeah, it was a thought experiment just to illustrate exactly how crazy quantum mechanics really is and exactly how important this role of observation is. So, should I explain the experiment?

Demetri Kofinas: 12:38 Yes. Please explain. Please, please.

Sean Carroll: 12:40 You can do a double-slit experiment just classically with water or with light. So, you basically take a light beam and shine it through two slits in some sort of barrier. And what happens if light were particles, what you'd expect is that the light would either go through one slit or the other. And you would see if you put a screen on the other side, you would see sort of one slit lighting up. Because when the photons, when the particles went through one slit, or one slit lighting up when it went to the other one. If light-

Demetri Kofinas: 13:14 Two lines of light against the wall.

Sean Carroll: 13:15 Two lines of light on the screen. Yeah, exactly. And so, if light were a wave like water or something like that, then as soon as that wave goes through either slit, it starts dispersing in sort of a wave-like spherical pattern, and you get an interference pattern on the other side.

Demetri Kofinas: 13:31 Because each wave is canceling each other out wherever it-

Sean Carroll: 13:33 Because waves go up and down, and so they either are going to add together and you're going to get a big bright thing or they're going to cancel and you get nothing at all. So that's the difference between waves and particles, is that waves can cancel each other and particles can't. So, seeing an interference pattern in that double-slit experiment is evidence of wave-like behavior. So, when you do the experiment, even though they hadn't, they predicted what the result would be and they turned out to be correct. If you send light sufficiently, delicately or even if you send electrons through a slit like this, you see an interference pattern on the other side. You see if you build up lots of electrons hitting it or lots of photons hitting it, they appear to be bright and then dimmer and dimmer and dimmer in lines as you get further and further away.

Sean Carroll: 14:18 So that seems to say that both light and electrons are waves. Okay. But then the twist is the following, this is easy to do for electrons, hard to do for photons, put a little detector next to each individual slit. So, you have double-slits, that's just what the light or the electrons are going through before they hit the screen on the other side, but invent something that keeps track of which slit the electron goes through.

Demetri Kofinas: 14:45 At the slit before it goes through.

Sean Carroll: 14:46 Before it actually hits the screen. Okay. So then, you imagine if the electron were really a wave and were passing through both slits and giving you an interference pattern, then somehow the detector should say it went through both slits. And you see the interference pattern on the other side. That's not what happens. What happens is, every time the detector says the electron either went to the left slit or the right slit, and because you did that detection, the interference pattern disappears. Now it's like a particle. Now it's acting like it's just going to go to the right or to the left, there's no more interference pattern. So, this is supposed to be a vivid demonstration of the idea that matter, whether it's light or electrons or anything else, acts wave-like as long as we choose not to look at it. And it acts particle like when we observe it.

Demetri Kofinas: 15:36 So I have so many questions about this. And I don't know where to start. One obviously has to do with what qualifies as a measurement or a detection, which we won't forget to do, I'm sure. Another thing that comes to mind, this you didn't mention it, and you'll probably have to explain to the audience. But the density of the light or the area of the light represents the probability that you're going to find the electron in that particular location. And what I don't understand here is, if you're going to shine light in the way we think about it in a classical world, and you get these two lines of light against the screen, there's never been a case where there's light, let's say, at the other end of the screen.

Sean Carroll: 16:17 We have to be very careful here. And this is why it took decades to actually do the experiment, right? With light, you can do the experiment. And the easy part is sending it through two slits and seeing an interference pattern on the other side. And that interference pattern, I mean, we see interference patterns in light all the time. It depends on what the wavelength is. The wavelength is very, very short. Those interference patterns are going to be really, really close together. And if the slits are too far, you won't even see interference. But as long as you have the right wavelength and the slits are close enough, and everything is set up nicely, you will see an interference pattern that fades off as you go left.

Demetri Kofinas: 16:53 Okay. So maybe I shouldn't have used light, maybe I should have used the electron, right?

Sean Carroll: 16:56 Good.

Demetri Kofinas: 16:56 The discrete firing of electrons. In what situation would we'd ever see an electron at the other end of the screen if we're firing straight? What would account for that? In other words, is that part of just ... There's another example in your book and I've seen this before somewhere else, which is that we understand the world is being in tropic, that you can't move in reverse. But in Many-Worlds or in a quantum world, it is possible for the chalk to jump off the desk and write Beethoven's Ninth Symphony on the chalkboard. Is that sort of what-?

Sean Carroll: 17:22 It's sort of is like that. I mean, one of the features of quantum mechanics as we teach it is that you never know for sure what's going to happen. The best you can do is predict the probability of certain things happening. So, if you say, you never see the electron fly off way to the left or to the right, the answer is, well, you could, it's just really unlikely to see it there. But if you waited long enough, you'd see some electrons doing that. That's the rules of quantum mechanics.

Demetri Kofinas: 17:46 So does that mean that if we ... Now we're jumping the gun here. I don't want to go too far. I do want to bring us back, bring some coherence to it. But in Many-Worlds type scenario, does that mean that even though it's extremely unlikely for me to see somebody, let's say burst into flames, that there are many, many things that are so unlikely. In a classical world, if something is highly improbable, it is practically impossible. And there are many things that are practically impossible.

Demetri Kofinas: 18:12 But in a world where there are so many gazillion practically impossible things, is it possible that actually within our lifetime, we hear about something that happened, that we say could never possibly happened? Like, there was like some ... You know what I'm saying? But it did. Because actually if you think about it in terms of probability in the context of Many-Worlds scenario, it actually is likely that out of all the unlikely events of the world, this one thing actually did happen, and we considered to be supernatural.

Sean Carroll: 18:41 So the short answer is no.

Demetri Kofinas: 18:42 Interesting.

Sean Carroll: 18:43 And the longer answer is, you have to do the math. Like, forget about quantum mechanics, just consider shuffling cards. Let's imagine you shuffle cards and you were actually really good at shuffling cards in a random way. So, a good card shark can cheat and they can rearrange the cards however they want. But if you were really randomly shuffling cards and you said, I shuffle it once, and I look and I shuffle it again and I look, how likely is it that the cards will just arrange themselves in order? Ace, king, queen, jack, et cetera. Well, it will never happen in the lifetime of the universe, okay?

Sean Carroll: 19:18 The chances that if you did that once per second, from the Big Bang to today, that the cards would ever arrange themselves in the right order is really, really tiny. And even though it's really, really tiny, it's still way bigger than a piece of chalk jumping up and writing Beethoven's Fifth Symphony on the board. So, when we say things are unlikely, these things that are unlikely are so unlikely that you've never seen them in the lifetime of the universe. Nobody's ever seen them in the lifetime of the universe. Don't worry about it.

Demetri Kofinas: 19:46 Fascinating. There was this other ... I read Gleick's, The Information, years ago, which I really loved and it really helped me a lot with information theory. And there was a part in the book where he talked about a particular book that had been published that actually generated random numbers. And it was basically a chapter about what is a random number. You had talked about doing something similar for the addition of your book. And I think your point was like-

Sean Carroll: 20:10 I did it.

Demetri Kofinas: 20:11 So you did it?

Sean Carroll: 20:12 That's right.

Demetri Kofinas:	20:13	I actually have to check the book and I didn't see that.
Sean Carroll:	20:15	So what I did was while writing the book, I generated a 50 digit, binary digits. So, 1001, et cetera. Quantum random number, so every digit was a single, yes, no measurement of the quantum mechanical system. And if you believe the Many-Worlds interpretation of quantum mechanics, which I'm sure we we'll get to, to specify, pretty soon, in different branches of the wave function in the universe, every possible string of digits came true. So, what I did was I printed that number that I got in the book, and furthermore, we put on the copyright page of the book, a version number, which was the sort of decimal expansion 735 quadrillion, et cetera. And so, I think that my book has the largest number of distinct editions of any book in the history of the universe.
Demetri Kofinas:	21:02	You were going to do that anyway, but did Rob Reed convince you to do it after you guys spoke? You guys did an interview together, and you had said that you wanted to do it-
Sean Carroll:	21:09	I had the idea. I just needed to convince the publisher to do it. And they actually loved the idea. So, yeah.
Demetri Kofinas:	21:13	They loved the idea. So, it was going to happen.
Sean Carroll:	21:15	So everyone, if you have a copy of the book, your version number is the same as all your friends version number, because you all live in the same universe. But there's copies of you in other universes that have different versions.
Demetri Kofinas:	21:25	Fascinating. So, let's go back to this thing about the detector and what constitutes a measurement because something else I learned in preparing for this episode is that there is a lot of ... I kind of already knew it, I guess to some degree, but it was formalized. That there is a lot of confusion about quantum mechanics and a lot of people use it. It's like a blank slate on which people can project whatever their desires are. One of the popular interpretations is that quantum mechanics basically proves that consciousness is integral to the universe because without a conscious observer, nothing actually happens.
Sean Carroll:	22:08	Yeah. So that's incorrect but you can understand why people would say something like that. And they are perfectly respectable physicists who used to think about that.
Demetri Kofinas:	22:14	Does Chalmers still think way in his understanding of-
Sean Carroll:	22:18	So David Chalmers, who's a well-known philosopher of consciousness is too cagey to ever say what he believes. And I'll give him credit. He's open minded about these things. So, he wants to insist that we should take certain ideas seriously. But he's not going to say because they're true, he's going to say, because we don't know and they have a chance to be true. So, he's absolutely open to the possibility that quantum mechanics and consciousness do have something to do with-
Demetri Kofinas:	22:42	He's more like Cartesian a little bit. No?

Sean Carroll:	22:44	Not really. So, a good Cartesian would say that the mind is a whole separate substance, right? There's the body, the physical world, obeys the laws of physics. And there's the mind which is not located in time or space and somehow interacts with the body. Chalmers is way too sophisticated to buy into anything like that.
Demetri Kofinas:	23:01	Well, actually, this is what I meant. I meant that he ascribes to the idea that there could be a Cartesian demon?
Sean Carroll:	23:06	No, he doesn't. [crosstalk 00:23:08]. What he's more likely to believe, again, what he actually believes is difficult to pin down. But what he's more sympathetic to, is something called property dualism, where the only things that exist are physical objects like you and me and the electrons are made of and so forth. But these things have both physical properties and mental properties. So, in addition to an electron in your body, having electric charge and a location and a spin and things like that, it has a mental state. Maybe its mental state is very primitive, like it's a little bit happier or a little bit sad, but that's it.
Demetri Kofinas:	23:39	Everything's a little conscious. Is that kind of like panpsychism?
Sean Carroll:	23:42	It builds up to panpsychism. That's right. And so, the conscious experiences that you and I have subjectively, introspectively in our first-person perspective, build up because we're made of many different particles interacting in a certain way, all of which have a little bit of consciousness. I think this is completely wrong. But it is a perspective that people have.
Demetri Kofinas:	24:01	And how does that thread in with like Tononi's Integrated Information Theory?
Sean Carroll:	24:05	So Giulio Tononi has this idea called Integrated Information Theory, which I think is a good try that didn't work. And it's a try to define exactly what you mean by consciousness. And basically, he came up with a mathematical formula that describes how integrated the information within a system is. So, you can ask if you have a country like the United States, so that country is made of states, and the states have people in them, and the people have cells in them, and the cells have molecules in them, and the molecules have particles. And at every one of those levels, you can ask, how does the information within that system integrate into itself? And what he argues is that the individual self is the high point of integrated information. There's less information when you go to smaller systems and it's less integrated when you go to bigger systems. So that's the locus of consciousness.
Demetri Kofinas:	24:59	It's interesting. So, he actually converges on-
Sean Carroll:	25:00	That's the argument.
Demetri Kofinas:	25:01	It's so interesting.
Sean Carroll:	25:02	You can even imagine-
Demetri Kofinas:	25:03	That takes geocentrism to like a new level.

Sean Carroll:	25:07	Well, but you can also imagine that under the right circumstances, a mob of people might be the right conscious agent to pinpoint, right? The mob sort of take on a mind of their own, as we say, because people become so connected to each other when in certain circumstances. But people like Scott Aaronson have pointed out that if you took the information in the human brain and printed it out on piece of paper, that would be just as conscious by Tononi's definition.
Demetri Kofinas:	25:34	Really?
Sean Carroll:	25:34	Yeah.
Demetri Kofinas:	25:34	That doesn't work.
Sean Carroll:	25:35	It probably doesn't work, right? And Erickson also has a bunch of other examples, which we'd all, most of us would agree, are not conscious, but would have very high integrated information. And Tononi's response is, how do you know they're not conscious? And so that's where the panpsychism comes in. That everything by this construction count as a little bit conscious because there's a little bit of integrated information, but less than you and I do.
Demetri Kofinas:	25:58	So I listened to a bunch of ... You have a great podcast. Congratulations. It's fantastic.
Sean Carroll:	26:03	MindScape. In fact, we just had-
Demetri Kofinas:	26:06	MindScape Podcast.
Sean Carroll:	26:06	Just had an episode with Philip Goff whose a big proponent of panpsychism.
Demetri Kofinas:	26:10	Couldn't follow it.
Sean Carroll:	26:12	But if you want to know what it's about, I think it's a good-
Demetri Kofinas:	26:14	Couldn't follow it. I listened to a number of them. It's super heady, obviously. And I'm sure if I didn't have all this prep stuff that I do every week, I bet that I would be listening to your podcast constantly, because it would give me that dosage. It stretches your brain. But I heard the episode on panpsychism, couldn't really follow it. I also listened to ... I mean, I first came across David Chalmers back when the third episode of the Matrix came out, and they had the installment of those documentaries. I don't know if you're familiar with it, but he was in that. He had long hair back then.
Sean Carroll:	26:45	I remember. Yeah.
Demetri Kofinas:	26:47	So I've always liked his stuff. But again, I can't follow his theory that well. I mean, I come from a point of view that I don't know that it makes sense that anything can be said definitively about our own conscious experience using science because sciences requires some objective measurement and conscious is entirely subjective.

Sean Carroll:	27:07	I mean, you're halfway to agreeing with Chalmers because people like him who, again, I disagree with, but I try to understand what they're saying. The main point that they want to emphasize following people like Tom Nagel, who's a philosopher at NYU also, is that there's something that is purely first person about consciousness. Something that I can experience and I can tell you what I'm experiencing, I can act in certain ways that indicate I'm experiencing, but you have no direct access to what I'm experiencing. And they say that's where consciousness lies, the experience of different things. And by definition, according to this way of thinking, can't be probed by outside observers doing ordinary scientific things.
Sean Carroll:	27:51	So that puts it in kind of a special category. People like me say that's just not right. Sure. If I'm sad, I'm experiencing something. But clearly, that has an impact on how we behave, also. I behave differently when I'm sad than when I'm happy. So, these inner experiences are not completely decoupled from the external, observable world.
Demetri Kofinas:	28:13	But like to kind of squish together the Cartesian demon thing and this, how on earth would you be able to prove if you were not in a simulation by some diabolical demon that some demon had created?
Sean Carroll:	28:24	You can't prove it.
Demetri Kofinas:	28:25	You can't prove it. So that's kind of what I'm trying to say, basically, which is that fundamentally, we can't make definitive statements about the subjective experience of conscious. It's kind of my point.
Sean Carroll:	28:35	You could be in a simulation and still be conscious?
Demetri Kofinas:	28:38	Yes.
Sean Carroll:	28:39	Right. So, the reason why this has anything to do with quantum mechanics is back in the battle days, when we knew that quantum mechanics had this rule that wave functions collapsed when they were observed, people definitely wondered about what do you mean by observing or measuring? And then they said, well, maybe it requires a conscious observer to do the measuring. And so very good physicist like Eugene Wigner, a Nobel Prize winner, set up entire strategies to figure out how consciousness causes collapse of the wave function. Now, Wigner later repudiated his ideas, but others still believe it. And it opened the door for people thinking that somehow consciousness creates the entirety of reality, one way or the other. And then you can make movies like What the Bleep Do We Know!? and stuff like that?
Demetri Kofinas:	29:23	Yeah, that was wild.
Sean Carroll:	29:24	It's all down there.
Demetri Kofinas:	29:25	That was wild. That was like some woman that was demonized or something, was in it. Like some person from like the world of Atlantis that had inhabited her body and she was called the Rom or something?

Sean Carroll: 29:36 Yeah, she channeled the spirit warriors, I recall. Yeah. There were various people of dubious legitimacy in there, and but people loved that movie. It was good PR for this point of view.

Demetri Kofinas: 29:45 Well, I think that speaks to the need for mystery in life, maybe. I think people ... That's a whole larger question about what's missing. Can we live in a world where we feel like everything is knowable? There need to be a certain amount of mystery for us to-

Sean Carroll: 30:01 I think that's part of it, but it's also if someone dispelled the mystery and said, yes, consciousness is central, it creates the universe, it creates reality. And here's how to use that lose weight and win friends, right? Then most of the people would say, that's great. I'm all for dispelling the mystery in that case. I think it's less about the mystery and more about the reluctance to give up on certain imagined powers that human people have. People like me think that we're constrained by the laws of physics and certain things we're never going to be able to do, including, for that matter, life after death. Right?

Demetri Kofinas: 30:35 So what causes the wave function to collapse?

Sean Carroll: 30:39 Again, that's what we don't know. That's what there are different proposals on the board in the battle days, in the Copenhagen interpretation, you're just not allowed to ask that question. You know it when you see it, that's the measurement problem. Like, when exactly does it happen? What causes it? How quickly does it happen? Now, these days, we have much better theories than the Copenhagen interpretation. They're rigorously defined, mathematically precise, and they get precise answers to the question, when does the wave function collapse or appear to collapse? But the answers are different in all the theories. And we don't know which theory is right.

Demetri Kofinas: 31:12 Do you think anyone is right in particular?

Sean Carroll: 31:14 I do. So, thank you for the leading question. Yeah, no, I think the Many-Worlds interpretation is right. And in many worlds, the answer is simple, wave functions never collapse. That's just not what happens. We apparently see wave functions collapse because when we look at quantum systems, what really happens is there's nothing special about looking or measuring or consciousness or perception. You are a quantum mechanical system just like the electron is and you become entangled with the electron. And if you're going to see the electron here or see it there, Many-World says, what really happens is that there are multiple copies of you that come into existence, and in each copy, there's a copy of you that saw it somewhere. And all the different places you might have seen it are realized in these different universes.

Demetri Kofinas: 31:59 So how does that work? So, this is the part that's so challenging. For me, personally, I think Most people, right?

Sean Carroll: 32:03 Yeah.

Demetri Kofinas: 32:05 And I wonder, Is it because we've grown up with a classical model of the world in our heads that we've been taught? Is it that there's something innately not right about this theory in the way that we experience the world? Or is it some combination that because we've also been taught Newtonian mechanics that it's sort of really ingrained in us?

Sean Carroll:	32:26	I think it's because it's ingrained in us, and not only because we've been taught, but it is our, as philosophers say, pre-theoretic view of the world, right? Like, you have to be taught anything to see like, here's a table, here's a chair, they're located somewhere in space, they move or they don't move or whatever. All of these concepts long before you learn about Newtonian mechanics, these concepts make sense to you. They're objects and they have locations. And quantum mechanics says, none of that is true. It's much more subtle than that. But if you back up and ask why in the world anyone would believe this craziness of the Many-Worlds interpretation, it's much simpler than any other approach to understanding quantum mechanics.
Sean Carroll:	33:04	So first you have to admit that quantum systems can be in superpositions. What we mean by that is, you can think of the electron, I said it's a wave. And if you observe it, you can see it in different positions. One way of saying exactly that, but just in different words is, the electron is in a superposition of every possible location that it can be in. It's not in any one location, it's in the superposition of all of them. Or Schrödinger's cat is in a superposition to being alive and being dead. Or the spin of an electron is in a superposition of spinning clockwise, spinning counterclockwise. So, it's not just that the electron is clockwise or counterclockwise spinning, we don't know, it really is in a superposition of both.
Demetri Kofinas:	33:45	How does time relate to that? If we're looking, for example, at the entire universe, does that mean that every single possible thing that can and will happen in the universe is there at this moment?
Sean Carroll:	33:56	No. I mean, the wave function of the universe says that certain possibilities are realized and certain ones are not. So, it's not just anything goes. The wave function says there's more of some things happening than other things happening. And so, the superposition is not equal. Like, when you think of the electron as being a little cloud localized near the nucleus, you can think of it as a superposition of every single possible location. But the chances, were you to observe it, that it will be far away from the nucleus or infinitesimally small.
Demetri Kofinas:	34:21	Also, the amplitude of the wave function is the total set of probabilities.
Sean Carroll:	34:25	The amplitude squared gives you the probability.
Demetri Kofinas:	34:26	It's the amplitude squared. So, when you're talking about the entire electron field being the quantum field or all the positions of the electron around the nucleus is the wave function. Is that a physical statement? Or is it mathematical that it's ... Because you're saying it's not, in fact, empty space?
Sean Carroll:	34:43	Right.
Demetri Kofinas:	34:44	But does that mean it's actually there and it's actually there in a physical form?
Sean Carroll:	34:48	Well, this depends on what your favorite version of quantum mechanics is. So, I would say yes, that's exactly what it means.

Demetri Kofinas:	34:53	And that's your interpretation. It's there in a physical form. Does that mean the universe is more dense than we think it is?
Sean Carroll:	34:59	Well, it means that the world is not made of stuff with locations in space. The world is one big giant wave function. That's what it is.
Demetri Kofinas:	35:09	And this where we talk about Hilbert space, the whole world is Hilbert space.
Sean Carroll:	35:09	That's right. The Hilbert space is the set of all possible wave functions. So, the world is one element of Hilbert space.
Demetri Kofinas:	35:09	One element. The universe is one element of Hilbert space. But Hilbert space is a mathematical construction.
Sean Carroll:	35:22	Well, it's always velocity. But that doesn't make it less real. The math is just the language we use to talk about reality. When I say that the world is a wave function, if you want to be a little bit more careful, what I really mean is, there's a world and it can be mathematically precisely represented by a corresponding wave function. But there's the world. It's not math, it's-
Demetri Kofinas:	35:43	Right, exactly.
Sean Carroll:	35:43	It's the world. It's reality.
Demetri Kofinas:	35:47	Okay. So, flushes out a bit more for me, because I think you actually, hadn't fully completed, I interrupted you when you were building out what the Many-Worlds system would look like.
Sean Carroll:	35:56	So there's three ingredients you need to bring. One is that quantum mechanics describes systems as being in superpositions. Okay. Number two, you are a quantum system. Back in the battle days with the Copenhagen interpretation, they said that you the observer are actually classical. You obey Isaac Newton's laws, whereas the thing you're looking at is quantum. And people like Hugh Everett who pioneered the Many-Worlds interpretation said like, come on, you're made of atoms. Atoms obey quantum mechanics, you obey quantum mechanics, too. So, you are part of the wave function.
Sean Carroll:	36:29	And number three, the third ingredient is this thing called entanglement. So, it's not that different parts of the universe, electrons or people or cats or whatever, have different wave functions. There's only one wave function for the whole universe, all at once. And that wave function says, well, if this is observed to be true, then we know something else. So, it's like you have two spins, you can have two spins, where you know that the two spins are aligned in opposite directions. But you don't know which direction either one of them is aligned in. So possible spin one is up and spin two is down. Possible spend two is down, spin is one is up.
Sean Carroll:	37:07	The reality is a superposition of both. So those three ingredients, things are in superpositions, you are quantum mechanical and entanglement happens. And then you just plug into the equations and see what happens. So, whatever it says is, when you measure the spin of an electron, it's not that it's wave function collapses into being spinning clockwise or spinning counterclockwise,

what happens is you are a physical system that has a wave function that is part of the wave function of the universe. You become entangled with the electron and the wave function of the universe becomes the electron is spin up, plus you saw it spin up, plus the electron was spin down and you saw it spin down. And both of those possibilities are still there in the wave function. And everyone agrees on that.

Sean Carroll: 37:51 Everyone agrees that if you follow the equations, that is what happens. Where people disagree is, what are you going to do about that? Whatever it does about it says, accept it. Deal with it. Chill out. Don't deny it. Just accept that. And what you say is that there are two separate worlds, one which says you saw the electron spinning clockwise. The other one, you saw it spinning counterclockwise. Every other version of quantum mechanics says is somehow we have to get rid of the other worlds. The other worlds are there. We all agree on that. So, we have to sort of delete them somehow. And so, there's different strategies for actually doing that.

Demetri Kofinas: 38:25 Because the Copenhagen view is, first of all, it differentiates between not only that you as an individual are living in a classical world or a classical system, that you are a classical system. But that in effect, the macroscopic world is classical and the microscopic world is quantum. And that you're kind of opening your little quantum window from your classical house, and you're viewing something in the quantum world. And then your classical observation collapses the wave function.

Sean Carroll: 38:55 That's exactly right. That's the Copenhagen story. And Everett says, you don't get the right to be classical. You have a wave function or you're part of the universal wave function. And that wave function branches into different possibilities when you become entangled with the small quantum system. So, this mystery in Copenhagen, what do you mean by measure or look at or observed is answered in many worlds by you become entangled with that small quantum system? That's the answer.

Demetri Kofinas: 39:22 So what does this mean in practical terms? Let's say it is in fact true. And there are so many other universes. By the way, another thing I mentioned, last night I was on Twitter and in preparation for this conversation, I put out a tweet because I had a question, which I already asked, which had to do with like supernatural phenomenon probability. But no one actually even wanted to hear the question I tweeted-

Sean Carroll: 39:45 Tweeter is not the best way to get new information.

Demetri Kofinas: 39:46 Everyone started giving me answers, I hadn't even asked the question. It was very funny. But back to this question, which is what does this mean in practical terms? How does this impact the way that we think about the world? Are you saying that if in practical terms the world is classical or our personal world is classical, but because the actual world is quantum that there are lots of other "classical worlds"?

Sean Carroll: 40:09 Yeah. Now, this is actually a great question. So, one really important thing for supporters of Everett like myself to admit, is that the fundamental formulation of the theory is really, really simple. But connecting it to the world we see is the tricky part. That's the difference. It's a vast distance between the formalism and our reality. So, what you would like to show is that out of this very austere, pure, simple, elegant formalism comes a world that more or less acts classically, except for some occasional quantum probabilities, poking their heads in.

Sean Carroll: 40:46 So when a radioactive decay happens, we can't predict when it's going to happen, right? There's a probability for any individual nucleus to decay. And so, if you have something like a Geiger counter that is clicking, because it's detecting radioactive particles, the laws of classical mechanics are not up to the job to predict exactly when that's going to happen. So basically, you hope that the individual worlds within the Everettian wave function act classically, except for some occasional probabilistic quantum interventions.

Demetri Kofinas: 41:17 Can I ask you something? First of all, when did you become interested in physics?

Sean Carroll: 41:22 Very young, 10 years old, maybe.

Demetri Kofinas: 41:24 Okay. So, as you progressed, I'm sure there were periods or moments where you came upon some significant realization about the world based on the things that you were reading. Over that time as your life has progressed and you've learned more and more, spend more and more time with this, and you speak with so many different people and you have all these conversations. How has this impacted the way you view life, your place on Earth, the world, et cetera?

Sean Carroll: 41:54 Well, I mean, that's always a give and take. I think that the way that we have assembling our view of life and our place in the world is not a straight line, usually, right? Like we have a lot of different influences coming at us. So, for me part of that influence is how the world works, the laws of physics and so forth. Part of it is reading and part of it is philosophy and part of it is talking to other people, and part of it is just thinking for myself. So I do think that my familiarity with how physics works, gives me great confidence in what we unimaginably call physicalism as a view of the world. Physicalism as in meaning, there's not extra properties that are mental properties that the world has. There's not extranonphysicall stuff, whether it's-

Demetri Kofinas: 42:39 Is that like materialism? The same ideas?

Sean Carroll: 42:41 Materialism, physicalism, are almost synonymous except the materialism says everything is matter or material. And I don't even want to go that far, because is a wave function matter? I don't know. Like, it doesn't really count. But whatever it is, the idea of physicalism is, it is stuff obeying laws of physics. That's the idea of physicalism. And it can really only be defined in contrast to alternatives. But I believe that. The success of the laws of physics is overwhelming. In my previous book, The Big Picture, I have an appendix where I write down this humongous equation, which encapsulates what we call The Core Theory, all of the laws of physics that apply to our everyday life as we currently understand it. And this theory is completely compatible with every experiment, everything you've seen here on Earth. [crosstalk 00:43:28].

Sean Carroll: 43:28 So we know the laws of physics governing you and me, here in this room. We know why the sun shines. We know why the planets orbit the sun, trees and puppies and all that. We know the underlying laws of physics. So, there's no room for extra stuff, influence and everything. And so that definitely affects how I think about purpose and mattering in life.

Demetri Kofinas: 43:47 I think, going back to the thing I said at the very beginning, this idea of the matrix or whatever. I think another way of putting it, I think, would be to say that I agree, but I agree with that in terms of epistemologically as an explanation. But I think because of the point about subjectivity, I don't know if we can use physics or science to make ontological statements about the nature of reality, you know what I mean?

Sean Carroll: 44:16 I do. [crosstalk 00:44:16] how you could better than physics when he made ontological statements. In fact, historically again and again, we've tried to guess at the ontology of the universe, and physics has proved us wrong over and over again.

Demetri Kofinas: 44:27 Yeah. But what I mean is, though, again, like you can have a simulation that operates perfectly that obeys all the laws of physics, you could be living in that simulation. And ultimately, it's not what you thought it was. So, this is also another way of saying-

Sean Carroll: 44:43 That's an epistemological question.

Demetri Kofinas: 44:43 Yeah.

Sean Carroll: 44:43 So that's a very good question. But I think it's a separate question. Like, if we had the theory of everything, the perfect laws of physics that really ... The core theory that I talked about in my previous book, I'm very careful to say that it applies within a certain regime, which includes our everyday life, but it doesn't include the Big Bang and black holes and dark matter and all these other things. So maybe someday we get the theory that does include all those things, we still wouldn't know that we weren't brains in vats or living in a simulation or anything like that. And so, what are we going to do about that? How much credence are we going to put on that possibility? That's an excellent question.

Demetri Kofinas: 45:16 Yeah. It's interesting that it matters for a lot of us.

Sean Carroll: 45:20 I'm going to give a talk on the philosophical question of how do we know what kind of universe we live in? How do we know where we live in the universe? If the universe is so big, there could be multiple copies of us. How do we know that we didn't randomly fluctuate into existence? How do we know we're not brains in vats? Can you use cosmology to figure out how likely it is that the laws of physics have different actual manifestation? So, these are all really ripe topics for the intersection of physics and philosophy. I think it's a fascinating set of questions.

Demetri Kofinas: 45:49 When are you giving that talk?

Sean Carroll: 45:51 Next Tuesday.

Demetri Kofinas: 45:51 Next Tuesday. Okay. This won't be out by then. So, little will have happened. But I can link the-

Sean Carroll:	45:56	Any time travelers listening should go back in time.
Demetri Kofinas:	45:59	I can link to that in the description.
Sean Carroll:	46:01	I have no idea whether it'll be recorded or not, but hopefully.
Demetri Kofinas:	46:03	Two questions popped into my head when we were talking. The first was more I bet you get cornered a lot at cocktail parties. That's sort of the first-
Sean Carroll:	46:12	There's some people who run away and some people who are fascinated. Yeah, it's two types of people in the world.
Demetri Kofinas:	46:16	Because if you were like creating a party, dropping you in would be like probably a good bet anywhere. Because there are not many people that can do that.
Sean Carroll:	46:24	I would probably just go play with the cat.
Demetri Kofinas:	46:27	Schrödinger's cat. I wonder also to what degree when people wonder about these things. Some like from the backdoor, from the side, their underlying questions about what happens to me when I die?
Sean Carroll:	46:41	Yeah, absolutely.
Demetri Kofinas:	46:42	Do you find that to be true with a lot of people that you talk to?
Sean Carroll:	46:45	Well, yeah. People don't want to die. I don't want to die. that's a very natural thing.
Demetri Kofinas:	46:50	Impermanence.
Sean Carroll:	46:51	Well, there's a lot going on here. I think that people don't quite appreciate what it would even mean to live even within an afterlife, literally forever. Right? We can't really tell the difference between a million years and infinity years, but there's a big difference there, right? I think you get bored after infinity years. But the fact that we all want to continue our existence makes it very natural that in circumstances of incomplete knowledge, we're going to bet that hopefully we do, continue our existence. But I think that the laws of physics provide really strong evidence that that's not what actually happens.
Demetri Kofinas:	47:24	Like entropy. Although that probably is also a bit dubious when we think about a quantum universe or no? Does that ... Or our notions of entropy change?
Sean Carroll:	47:35	Notions of entropy don't change, but there are unlikely things that happen. But again, those unlikely things are so really, really, really, really unlikely that for all intents and purposes, forget about.
Demetri Kofinas:	47:48	Something else popped into my head when we were talking about this immortality, is it really about death? Or is it even more fundamentally about not knowing the uncertainty of what comes after that?
Sean Carroll:	47:58	I don't know. I think people want to live forever.

Demetri Kofinas:	47:59	Yeah. So, you don't think there's less anxiety around that within the physics community, because you guys are actively dealing with these questions? And so, trying to work through that gives you a sense of catharsis around these issues, because you're-
Sean Carroll:	48:12	Sadly, no. I mean, that would be great. I think that effectively, the vast majority of working physicists are physicalists and atheists. And if you ask them, they would think that there is no life after death. But they don't spend a lot of time thinking about it, because there's another thing going on, which is that physicists are highly trained to spend their time thinking about physics, and not worry about questions that might distract them from physics.
Demetri Kofinas:	48:34	So I have another question that kind of comes into this. Well, actually, maybe an easy way to get into it is talk about QBism. Because it doesn't QBism view quantum mechanics or the observations that come out of quantum mechanics as being basically just another way of describing probabilities?
Sean Carroll:	48:52	Yeah. So, for those of you out there who are not experts or haven't read my book yet, QBism is spelled with a Q, not with a C, so it's not the art movement. Quantum Bayesianism is the phrase from which QBism was derived. And it's basically an approach that says, forget about reality. Forget about the real world, forget about ontology, forget about what's really going on. Limit yourself to saying we are agents who make predictions for what is going to be observed. And then in that case, you say the wave function doesn't represent reality at all. It's just a tool we use, we agents, we use this tool to make observations of reality and make predictions. And even two different people could have two different wave functions for the same system. They might know different amounts of stuff.
Sean Carroll:	49:37	And then they use this philosophy to build up an elaborate set of mathematical relationships, improved theorems and things like that. And for someone like me, it's just wildly unsatisfying. Like, I want to know what reality is. That's the whole point. And some quantum Bayesians or people who work on epistemic approaches to quantum mechanics more broadly, where you say the wave function is not reality, is just a way of making predictions. Some of them say, yes, there is a reality out there, we haven't quite figured out what it should be within this picture. But people who've tried have failed to come up with any reality other than something like the wave function.
Demetri Kofinas:	50:13	But QBists would say that reality is classical, right?
Sean Carroll:	50:16	I don't even think they would say that.
Demetri Kofinas:	50:18	They wouldn't say that.
Sean Carroll:	50:19	They would say, why are you talking about reality? Talk about measurement and outcomes.
Demetri Kofinas:	50:21	So they actually have that embedded in their philosophy?
Sean Carroll:	50:23	Yeah.

Demetri Kofinas: 50:24 Can you take the operational framework or model of QBism and apply it, and at the same time also believe that the world is classical? In other words, because this is giving you-

Sean Carroll: 50:36 But believing that the world is classical is a statement of ontology of what the world really is. Quantum Bayesians want to say that all the world is a set of measurement outcomes. So, reality comes into being as a result of our measurement outcomes.

Demetri Kofinas: 50:51 That's interesting. Man is the measure of all things, it's quite literally.

Sean Carroll: 50:53 Christopher Fuchs is one of the founders of quantum Bayesianism, calls it, participatory realism. Because by the sum of all of our measurement outcomes, we bring reality into existence.

Demetri Kofinas: 51:02 Highly relative.

Sean Carroll: 51:04 Yeah. I can't even claim to fairly characterize it, honestly. So, I don't even like talking about quantum Bayesianism, because even if I tried to be fair, I'm going to mess it up.

Demetri Kofinas: 51:15 This reminds of something else. I took, sad to admit it, because I feel like I should have done better. But I took an online course by Leonard Susskind some years ago. Of course, there's the famous phrase that Richard Feynman said that, pretty confident, that no one understands quantum mechanics.

Sean Carroll: 51:33 Yes.

Demetri Kofinas: 51:33 And that goes back to the point that I said early on when I read that book on quantum gravity where it said everyone's sitting at dinner, and putting aside the point about mathematics, no one can agree on what it actually is. But he had said something else that really resonated with me, which was that Feynman was reported to have said, "It's so confusing. I can't even tell if there's a problem."

Sean Carroll: 51:52 Right. That's right. Yeah. And I think that this is another message of my book, is that physicists, forget about the fact that we don't understand quantum mechanics. That's fine. There's plenty of things we don't understand, right? I mean, that's how science makes progress by not understanding things, recognizing we don't understand them, and trying to tackle the problem. The problem with quantum mechanics is we're not trying to tackle the problem. It's not that we don't understand it, it's that we are in denial about the fact we don't understand it. And there's a whole bunch of working physicists who say, it's fine that we don't understand it. Who wants to understand things? That's not why we're here. We just want to make predictions.

Demetri Kofinas: 52:28 So I have another question and it kind of intersects with something that I discussed with Patrick Grim on our episode on Mind-Body Philosophy, and that had to do with notions of the self. Who am I? And there were some thought experiments we worked through. And one example would be if I made a literal copy of myself, and that copy was recreated, who would I be? And that stems from your interpretation of many worlds.

Sean Carroll: 52:53 It's an example. Yeah. So, this is exactly what I'll be talking about in my philosophy lecture. This idea of personal identity over time, to the extent that we think of the world as classical and having, for that matter, just any single world version of reality. Again, even if we don't define it rigorously, we know what we mean when we say our self, right? You have a self and it's connected in an obvious way to what that self was doing a year ago, for example. But if we are really, really careful about it, yourself now, is it a different person than yourself a year ago? This is a person who knows different things, who's made of different atoms, right? Who has different knowledge and experience.

Sean Carroll: 53:32 So what's more rigorously true is there is a relationship between yourself now and yourself in the past. So Many-Worlds says that relationship is many-to-one. It's not one-to-one. There's one self in the past and as many selves right now. That's fine. That whole talk about what the relationship is and psychological continuity and the sharing of memories, still goes through unaffected. So, it's an updated version of what you mean by personal identity, but it's a perfectly coherent version.

Demetri Kofinas: 54:02 So what do you think consciousness is?

Sean Carroll: 54:05 I think consciousness is an emergent phenomenon. It's a useful way of talking about the fact that we are made of atoms, we're a physical system that has the property that we contain information about ourselves. That we represent ourselves. That we have some form of self-awareness. And we can sort of check back on ourselves to figure out what is going on and that self-awareness.

Demetri Kofinas: 54:26 Doesn't it complicate you when you think about that, ultimately, consciousness was what's creating all of these theories? I don't know. I guess, the theories that I come across that try to explain consciousness ... Again, I think, here's where Chalmers makes more sense to me. I feel like consciousness somehow needs to be at the center. But again, even if it's at the center, I think where I disagree is I don't know that you can say anything definitively, if you put it at the center, because then it's just all theoretical. Right?

Sean Carroll: 54:55 I don't know because they don't put it at the center. So, I don't want to speak for people who do. I think that consciousness ... The universe would be fine without consciousness in it. So how in the world can we put it at center.

Demetri Kofinas: 55:05 All right. So, I'm going to move us to the overtime, Dr. Carroll, and I want to drill more into this maybe from a more practical standpoint or maybe popular culture standpoint, maybe talk a little bit more about the simulation, reverse engineering intelligence and stuff like that. For regular listeners, you know the drill. If you're new to the program or if you haven't subscribed yet, head over to patreon.com/hiddenforces, or go directly into the description for this week's episode and click on the link, and you can access our audio file autodidact or super nerd tiers and get access to this week's overtime and my conversation with Dr. Carroll. As well as to the transcript of today's conversation, as well as to the rundown, which was my attempt at bringing some level of preparedness in order to this conversation. Dr. Carroll, stick around.

Sean Carroll: 55:57 I will. Thanks.

Demetri Kofinas: 55:59

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