Events and the Nature of Time: Anthony Aguirre

Source URL: https://www.closertotruth.com/interviews/55687

Transcript - Long

Robert Lawrence Kuhn:

Anthony, the nature of time is one of the most important topics in – in physics and indeed is one of the most important topics that FQXi has dealt with over the now 10 years of your – of existence – our existence. I'm pleased to be part of it. And – and the conference we're in now is on events and observers, so how do events, which indeed have a sequence, seemingly simple, affect our understanding of the nature of time?

Anthony Aguirre:

Yeah, it's– time, you know, time is interesting. We – we – the way we experience it, we divide it into three very separate categories. You know, there's the past, things that happened; there's the future, things that might happen; and there's the present, things that are happening. But if you notice the common phrase between those things, it's happening. You know, things that are happening. Events. So, in – in a sense you can say events happen in time. You know, some events happen later than others, there's a flow of time and events, you know, take place during – during that flow. But maybe it's more accurate to say that time flows as events happen, you know, that the flowing of time, the passage of time, really is made up – its fabric – is things that are happening, is events.

Robert Lawrence Kuhn:

So, that's a radical distinction that sounds verbally very similar, but it is a – if you think about it – a shocking difference between the two. In one case, time is the absolute background in which events occur, and the other way, events are the primary thing and time is a derivative or something that emerges out of a sequence of events.

Anthony Aguirre:

Yeah. And this – and this goes very deep, these two sort of points of view because one is a little bit the – the sort of general relativity view, there's this background. General relativity is a, you know, the theory of space and time, space and time is there, it affects stuff but – but, more importantly, stuff moves around in space and time, so events happen in space and time, things evolve in space and time but they're there already. And, on the other hand, we can think of quantum mechanics where, especially if you think about quantum gravity where space and time themselves are quantum mechanical things, the only way that time can pass is by quantum mechanical processes happening, events happening in quantum mechanics. So there's this real attention as to whether, you know, space-time is something that is fundamental and stuff is happening in it, or there's something else that's more fundamental and space-time and the passage of time is something that's coming out of that in a way that we really don't understand it.

Robert Lawrence Kuhn:

Right. Right. So, how do we make progress?

Anthony Aguirre:

One way I think we can make progress is to dial back the ambition a little bit from thinking about quantum gravity, it's super hard. Let's think about something a little bit easier which is just how things happen in quantum mechanics, how things happen in, even if we don't have quantum mechanics, just regular physics. So if we just imagine a bunch of particles following the laws of physics, nothing really happens. They each just do their thing according to the laws that they follow, but we might imagine that there are bunch of those particles that are in a ball here, and bunch that are in a ball here. The balls come together, they run into each other and something happens. But those things: a ball, a ball run into, happen, those are not things that are built into fundamental physics. Those are things that we describe, you know, so we've added a whole bunch of information. We've added, you know, things together. We've added locality, close together in space. We've added, you know, irreversibility where things can smash into each other but not un-smash. So these are things that don't really exist in those fundamental laws. Those are very simple ones that we describe of – of just particles going through space, but are they unreal? Not – you know, balls smashing into each other is a real thing. It's important. If one smashes into your head, you care. So, these are things that we care about, but aren't there in fundamental physics. So where are they? You know, how do they get produced? How do we understand what exactly their relation is? So even that problem is quite hard, but really sort of understanding how these – so – so-called emergent phenomena, things like stuff running into each other, comes out of fundamental physics, I think will really shed some light on how we can think of deeper questions like quantum gravity.

Robert Lawrence Kuhn:

So how does this affect the nature of time, then? If you're – if you have this, ah, complexity in going from the fundamental physics of the wave function and probabilistic to the – to the discreet balls bouncing into each other, ah, when you have these two different ways of thinking about it, how does the capacity to unify that, so you can go from one to the other, how does that affect our notion of time?

Anthony Aguirre:

So, we can maybe take a few different views of time. One is that, ah, we might call the general relativity view of time, that space and time is laid out, there is something we call the past and future and now, but those are just kind of artifacts of where we happen to be. It's all there. You know, it's all laid out. This is the – the block universe view. Then the question is how do we get from that view to the one that we experience, which has passage of time and events happening and so on. There's another point of view that one might have that passage of time is fundamentally real; that the future really doesn't exist yet, but the past really is fixed and we can't affect it and now is kind of genuinely and objectively special place in the universe. I don't – you know, most physicists tend toward the – the former view.

Robert Lawrence Kuhn:

The block universe.

Anthony Aguirre:

The block universe, but—

Robert Lawrence Kuhn:

Which is general relativity founded, yeah.

Anthony Aguirre:

But either one of them leads to pretty confusing questions. [Laughter.]

Robert Lawrence Kuhn:

Right, right.

Anthony Aguirre:

If you take the – the view that now is objectively real, how do you reconcile that with special relativity? Because special relativity tells you that the things that we say are happening now depends on your reference frame. Who, you know – everybody has their own now in special relativity. It can depend on how fast they're moving and so on, so you can't agree on what is now, so how can it be objective? But if you take the other, the block universe view, then how do you get back all the stuff you've lost? How do you get back the passage of time? How do you get back things that happen in a future that is free and a past that is seemingly fixed? And – and why are those so strict? You know, if it's something that we've kind of made up, the – if the real reality is this block and we've just made up the past and future, why can't I go back and fix some of those mistakes I made, you know, or – or why can't I look into the future and see it like I can the past? It's very, very strict. You know, the – these – these, although they seem like fictitious, are very strict rules. We really can't do it. So – so they have that – the – the character of kind of fundamental law, but where those laws come from, how they emerge is – is somehow soft and squishy and we can't quite get at it.

Robert Lawrence Kuhn:

So now, take that same analysis for quantum mechanics so we understand both sides of it. So how does time, then, work in quantum mechanics?

Anthony Aguirre:

Now, in quantum mechanics the – the sort of distinction between the – the sort of quantum mechanics block universe, if you will, and things happening is even more extreme in a sense because quantum mechanics has sort of two rules. Rule one is you've got the state of a system, the quantum state of a system, and you've got an equation that just evolves that state forward or backward in time. You can turn the crank that way, you can turn the crank that way. It'll tell you exactly what state the system is in, the quantum state, at any given time, infinitely into the future or past. It's like the block universe. There's nothing new that happens. But it's got this totally second separate rule that says, oh, but if you look, if you make a measurement, then something irreversible happens. There's a change, there's an event where you go from this, you know—

Robert Lawrence Kuhn:

Probability.

Anthony Aguirre:

—determined evolution to suddenly changing the state of a thing into it's here, or it's there, or this happened, or that happened. So it's this funny thing where the – the – the evolution of time is kind of this really boring thing, this mathematical evolution, but happening is this really weird and interesting thing that you just stick into the rules of quantum mechanics. You just add it on. And those two – the fact that there – there are those two, is really hard to understand. That's the core of the quantum measurement problem and the – when you make a measurement, it has a – an – a really important aspect to it, which is that it's irreversible. Once you make that measurement you cannot go back. You can't unmake it, you can't reverse it. You've done something that has distinguished the past from the future by the present. It's just baked into the way we do quantum mechanics. And, how do we then understand that kind of effective, incredibly effective and useful rule that we've baked in, you know, how do we understand what that really means?

Robert Lawrence Kuhn:

So, though we may not know what time is in reality, we know at least in the formulations, they're different in general relativity and quantum mechanics.

Anthony Aguirre:

Yeah, we don't understand it in quantum mechanics, we don't understand it in general relativity, but we don't understand it in different ways in both of them.