Time Tries All Things

Grace Weir, 2019

Audio Transcript

DAVID:

I think when people talk about time they often confuse two sorts of thing.

There is time itself and there is what's called the arrow of time, which is direction, and its perceived nature as a human being.

In other words, what we mean when we say something is before something else or after.

In General Relativity, time is not that special in the sense that it combines with space to make one four-dimensional entity of spacetime.

And it's so much not different to space, that space and time can sort of rotate into each other.

When we do ordinary rotations we have this perspective in space.

And the reason why all human beings have got such good intuition for rotations is that we can rotate ourselves, and we get used to the fact.

The strange bit about the transformations that rotate time and space together is that that happens based on how quickly we move relative to the speed of light.

Now, the problem is we move very slowly so that's always about zero.

The result of that is, imagine everyone goes through life on a rotating chair but they can't rotate it. So, everyone faces the same way.

When you all face the same way you forget that you can rotate the thing, you spend the whole time everyone agreeing that this direction is separate to the others.

But not to nature. It's full of particles moving near the speed of light so they can always naturally combine space and time into one thing.

It's only because we are forced to face one way because we can't move quickly enough, which gives us a psychological distinction between space and time.

We can make a simple two-dimensional diagram where we label where we are in space and where we are in time and we think of ourselves at the origin.

Then because nothing can travel faster than the speed of light, this creates a cone in spacetime, centred at the origin.

All of the points here are in our future. We can influence them, cause things to change in this cone, and here, in our past, are the things that can influence us.

Here though is neither future nor past.

Because the speed of light is finite means that the past and future doesn't break up all of spacetime.

There are bits of spacetime that are neither in the past or future of a given point.

Because we move so much more slowly than the speed of light, we don't see that.

As the speed of light increases, then that cone gets wider and wider and there's more future and past.

Until how we perceive the world now where the speed of light is infinite, then we divide all of spacetime into future and past.

And that's how we perceive the world.

It's as if for us, the speed of light's infinite and all of spacetime is divided into future and past.

But in reality, that's not true.

The speed of light is not really about something moving, it's almost the opposite.

It's about how the causal structure of space changes from future and past.

FAY:

Being or becoming is an ancient question.

Ever since we have records of people thinking about the world, in ancient Greek philosophy for example, there have been people on both sides of this debate.

One view is that the universe just simply is and that it just exists, in what is called the block universe view, and the other is that the essential nature of the world is that of change and becoming.

The block universe stretches from the beginning of time to the end of time and every event is in it, including all future events.

General Relativity seems to support the block view. In General Relativity, there's no concept of three-dimensional space with three-dimensional entities like tables and human beings.

There is no sense in which there is an existing 'now' because there is no such thing as a global 'now'.

There is just a four-dimensional history, the block.

I think that conceiving of the universe as a block misses something fundamental about our experience of the world, the dynamic aspect of our experience is missing.

The block doesn't have anything that corresponds to the happening, to the actual occurrence of events.

We experience time passing, and it's probably the most basic aspect of our perception, this temporality of our experience.

Some don't take it seriously as evidence for anything, some even say it's an illusion. I do take it seriously. It suggests we should incorporate becoming into physics.

Becoming is the process of coming into being.

If you add to the block view the concept of becoming, then the block isn't fixed but is a growing block, something in which the past exists but the future doesn't exist yet.

DAVID:

People say the speed of light is a fundamental constant of nature. Why is it 29 million 979 thousand metres per second?

But that number would change if you change what a metre was or what a second was.

The original definition of a metre was very arbitrary, very nationalistic, very human.

Defined by the French after the Revolution, the new measure was equal to one ten-millionth of the length of the distance from the North Pole to the Equator, measured along the meridian passing through Paris.

Then they made a bar in platinum as the definitive metre.

Of course, they didn't really know the distance from the North Pole to the Equator, so really it was still just a platinum bar.

But that can't be anything to do with nature.

Eventually they realised that the bar wasn't very replicable and they came up with a better idea.

But it's arbitrary. And the second is arbitrary.

The point is when you measure the speed of light in metres per second that number actually means nothing, because if I change the metre or the second, that number changes.

The reason why that number is there is just through our choice of unit.

So, the speed of light is the conversion factor between the units of time and the units of distance in space, so we can get an overall distance in spacetime.

You realise then, you can have space and time to really be one thing.

It's much more crucial than treating time specially.

Treating time specially is a human construct and we're using the wrong language.

And at the very basic level that's not how nature works.

FAY:

My own view is that nature is fundamentally discrete and that there's nothing continuous about it, fundamentally.

An event is something that can happen, localised in space and time. If you take that concept and you just make it smaller, in a smaller region of space, lasting for a shorter amount of time, and you just keep going and going, then the hypothesis of atomicity is that you can't keep going, making it infinitely small.

So just as matter is atomic and there's a limit to how small you can cut it up, there's a limit to how small you can make an event.

And that limit is called a spacetime atom.

So a spacetime atom is the smallest event from which all other events are comprised.

The idea is that our experience of some duration of time is actually an experience of the coming into being of a number of discrete spacetime atoms.

A very large number and those events follow so closely one after the other, that they can't be distinguished as far as we're concerned.

So continuity arises, emerges as an effective description at larger scales than the tiny fundamental scale.

My argument is that, in this way of understanding the world, you need the spacetime atoms but their coming into being or birth is a distinct and necessary thing too.

The process is also physical and real.

So, for me the discreteness is crucial here, because this birth process is hard for me to conceive of in a continuum.

This birth process doesn't stop, it goes on, it's inexorable, it's just like time because the process *is* time.

Tomorrow *will* come.

So there are two real things: one is spacetime and the other is the process of it coming into being.

Once the spacetime atoms have come into being, then they are part of the past.

Already within this discrete atomic theory of spacetime, there is something quantum about it, in the sense that there are smallest units of spacetime. And that's one of the ideas that underlies quantum theory.

But the theory that we have at the moment, the model of the coming into being of these spacetime atoms is not yet fully quantum mechanical, because it doesn't include the crucial aspect of quantum theory called 'interference'.

That is when what happens is influenced by everything that could happen, which is not comprehensible by classical logical rules of inference.

So an electron will change its behaviour depending on what other choices are available to it, choices of things it could do.

The whole set of possible things that a quantum mechanical system could do changes what the system actually does.

DAVID:

Why do we have an arrow to time? That's a separate question of what time is.

The arrow is related to our human perception of spacetime.

The general consensus about the human perception of the arrow of time is through thermodynamics, which says that entropy grows.

Entropy is a measure of disorder and that disorder grows, because there are more disordered states than there are ordered ones.

The arrow of time, as seen in human perception, is driven by that thermodynamic arrow of entropy increasing, which is separate to what time is.

It’s also very much tied up to being large scale, because if you’re an individual atom you won’t see that arrow. In that sense the arrow of time needs a scale.

There is a fundamental randomness to nature. It introduces a scale and says nature doesn’t behave the same way at different scales.

As you change the scale in which you look at nature you’ll behave differently and the smaller you look the more random things get.

So, how do we combine the randomness of quantum mechanics with its scale dependence, with spacetime bending and stretching?

FAY:

Spacetime grows via this process of these spacetime atoms being born, which is an asynchronous process, there’s no physical sense in which two events happen at the same time.

Two events might happen one before the other or they might not.

If they don’t happen one before the other, they’re not happening simultaneously, they just don’t have an order at all.

However, if I want to represent two unordered events and I represent this event by making a picture of it and I represent this other event by making a picture of it, I have to draw one first and then the other one.

But it’s not that one happens first physically, they have no physical order.

There’s no external time, time is the order in which the spacetime atoms are born.

One birth event may precede another birth event, and the hypothesis is that, that order of the events, is time.

Time is order and this accords with our experience. We experience temporality as an ordering. We experience one thing after another.

DAVID:

As physicists we are attempting to get closer and closer to nature, but nature is more complex than our description of it.

One of the assumptions that we make is that the basic building blocks of nature are point-like.

And it really comes back from the Greeks who had this whole love of spheres and balls and these dots – perfect, infinitesimal dots.

The Greeks gave us that vision; we accepted it, but why?

Let's go, instead of there being infinitesimal point-like dots to nature, let's start with objects which have one dimension, that will be like a piece of string.

You can't tell the difference between a super small loop and a point if you can't see that closely.

What this does is give you a minimal distance to nature, whereby you can't go smaller than the string length.

Strings can do something that points can't do, which is that they can vibrate.

There are natural frequencies. In those vibrational modes, the particles will look different.

So, it gives you the possibility of having what looks like two different objects, coming from one object, vibrating differently.

Duality is where we discover that nature has two seemingly very different systems, that are really hidden, deep down, the same system, but our description is different.

It's a sign that our language differentiates between two things, which are actually the same, that what we thought of as different geometries in space and time may not be different.

This is always the thing that one has to distinguish. The description that you have of something and what the thing is.

There's something deeper here that's not manifest in the descriptions that we've got, that shows that those descriptions are not adequate.

If you had the right description of nature there wouldn't be any duality. Half the problem is our intuition is built on these descriptions.

You're left then with the consequences of removing the point from nature.

You think of how geometry is formulated at its most fundamental level, it's in terms of points.

When we remove the idea of a point, it means spacetime itself has an additional fuzziness, an uncertainty between where you are in time and where you are in space.

Meaning: when we had points in spacetime, you could know you're exactly *there*, at that point in space and time.

Now it could be that you're very uncertain in where you are and when you are; it's approximately here and approximately now.

And how much that approximately is, is dependent upon your size.

So, if you're very, very small you might not have any idea of time at all, there will be no notion of location or now.

It's only when you get much bigger, the structure is very different.

Why is it I feel I have a location in time? And then you realise: well, that could be taken away from you.

So, it's much more a way of thinking rather than an accurate thing of nature.

FAY:

There's a view of what science is, that the model that we create of the world, this model or theory is the only way we can approach the world at all in thought and in understanding.

That without the theory there's nothing to say at all.

Mathematicians build worlds, but they don't require any correspondence between experience and the statements within that mathematical world.

Physicists, though, require a correspondence between statements and our experiences.

The notion of the becoming process is within the theory and maybe even it does not fully capture the temporal aspect of our direct experience.

The asynchronous birth of spacetime atoms is a mathematical notion, which I can state but it's not something I can demonstrate. Because once it is demonstrated, it loses its essence as something dynamic.

The act of representing is a limiting factor. It introduces something which is not there physically.

Even articulating it creates a record, because it's in your memory, it's laid down in terms of chemical events that have happened in your brain.

So there are ways to convey, ways to describe or picture the birth process, which by the very depiction, cause some aspect of it to slip away, to be lost.

Time is a dynamic process, but communicating this concept makes it static.

We're trying to pin down in language and then in mathematics and physical theory something which is essentially fleeting.

Relativity says you can't understand something as it is 'now'.

I mean, it doesn't exist at a moment of time, that concept has no place in the theory.

In relativity, something is its history, and that history is continually growing.

That's what you are: you *are* your past history and that's changing, growing as time passes for you.

Your history accumulates more past events so you're different now than you were half an hour ago because more has happened.

All that you were in your past is part of you. Nothing that you were is lost, because what you are is your whole history.

That is the truth according to General Relativity, our best current theory of spacetime.

The question is, can we maintain the view that something is its history, and yet also release the world from being an already existing block?

Can we incorporate becoming? So that while the past is real, the future doesn't exist yet, the future is open.