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4 Is reality what we make it?

So, by now we have established what our reigning paradigm is and heard why it is time to renew it. We have discussed that there are aspects of our reality that are simply not in keeping with the way we view the world: there is no convincing scientific explanation for consciousness; we do not understand how brain function can result in the experience of feeling like somebody. Furthermore, modern-day physics is telling us our world looks very different at the subatomic scale, where quantum systems have both particle and wave-like properties and only take on one or the other when they are measured. We need a new paradigm that can incorporate these as yet poorly understood aspects of our reality.

What shape should this new paradigm then take? We have already heard that it should build on our existing paradigm, but be more organic and circular and less atomistic and deterministic. The second half of this book explores the ways in which our understanding of the world is changing. It is not the goal to provide a complete picture of what science will look like in 50 years, rather the idea is to sketch an outline, with shadows here and there, leaving the reader to peer through the looking glass and make up her own mind as to what she sees. An obvious place to start is with the question how the probabilistic world of subatomic processes creates the definitive physical world we perceive around us. Erik Verlinde explained why reality appears as it does as follows:

Reality: just probabilities taking shape?

The reason our reality appears very classical rather than quantum mechanical to us – in terms of objects having definite positions for example – is through a process called decoherence.⁴³ When you think about it carefully, it also has to do with entanglement: if I

43 See note 30 and Lexicon.

have a bit⁴⁴ over here that is in one of two conditions (0 or 1) and I bring a measuring device close to it, what happens is that the outcome of the bit becomes entwined with the measuring apparatus. The apparatus is macroscopic and has so many conditions, lots of 0s and 1s, that the little bit no longer has its conditions. So really you are projecting your measurement by entanglement.

Ton: It becomes one system.

Erik: You can't see the other possibilities. The other possibilities disappear from the system.

Sarah: That's fascinating! I had never thought about it like that before. You're saying that when you do a measurement, the measurement apparatus becomes entangled with the system you are trying to measure. But then that keeps the problem going: If the apparatus has become entangled and you, as the experimenter, are outside the system, you still wouldn't know what the outcome of the measurement was. Would you? Not until you became entangled yourself...

Erik: That's right. That leads to dilemmas like Schrödinger's cat and the like...

Schrödinger's cat is a famous thought experiment coined by Erwin Schrödinger in 1935. It describes a cat in a box with a vial of poison attached to a monitor for radioactivity and a radioactive source. If the monitor detects a radioactive particle the vial is shattered and the cat killed. In orthodox quantum mechanics, the cat is interpreted as being simultaneously dead and alive until you open the box, at which point the system (cat) takes on one or the other value.⁴⁵

Erik continues: My feeling is we have a very practical solution for that in quantum physics, but when you think about it philosophically: Is there a wave function collapse or isn't there?

44 The term 'bit' originally comes from computing and means 'binary unit'. It is the basic unit of information and may have one of two values, often denoted as 0/1.

45 Also see Lexicon.

Sarah: perhaps we are not thinking about it with the right paradigm...

Erik: Well... certainly the world is more quantum mechanical than we realise in our daily life.

The problem of how reality – as we perceive it at the scale of our daily lives – emerges from a subatomic probabilistic reality is something we discussed a lot. As Erik says above, quantum physicists have often described it as a quantum probability wave collapsing when a measurement is made. Yet, the mechanism of it is hard to understand. Ton said:

I think that when we observe something, it is our experience, at least for a while, that we have acquired some certainty and constancy. But then again, we all have plenty of experience with change and growth and decay, the sense that nothing stays forever, '*panta rhei*'.⁴⁶ So no, I don't think the wave collapses into some sort of singularity. Not ever. I think that reality always continues to be constructed of possibilities, at least in some sense.

In talking to Alex Wendt:

Ton: About this concept of the collapse of the wave function: It seems like it is still described in classical terms, as if a wave of possibilities is collapsed, stops being possibilities and is actualised into some kind of certainty, a singularity. But how can that ever be? How long can such a certainty exist, given that as soon as something *is*, it starts moving forward and changing again?

Alex: I see what you are saying... The claim is that chance becomes fact at that moment for that particular state. But clearly whatever it was that collapsed, immediately returns to a wave function state. It is constantly collapsing, constantly. Whereas the metaphor of a collapse makes it sound as if it is terminal.

⁴⁶ Citation attributed to the ancient Greek philosopher Heraclitus, translates as 'everything flows'.

And you only get the terminal one when you die (*laughter*), that's the true collapse.

From the way I see it, what the wave function collapses into is our conscious experience. Each of our conscious experiences is the stuff that is being collapsed. And so each bit of consciousness, if you want to put it that way, would be a collapse. So, in that sense it is a continuous stream.

Ton: For how long?

Alex: That I don't know. A very, very short time.

Ton asked Erik more directly: What is a probability wave? How do you determine its boundaries?

Erik: Well, this is a century-old discussion about the interpretation of quantum mechanics. The new language of information we are developing is one that builds more on the more abstract language of quantum mechanics and does not concern itself with waves. Probability waves were introduced by Schrödinger to make quantum mechanics more visual. Bohr originally described it in terms of states, where you make jumps from one to the other.⁴⁷ And for that you don't need probability waves.

Ton: What sort of states?

Erik: Really it is nothing more than a way to describe a state. It gives you the probability of finding a certain result if you do a certain measurement. The probability wave is a complex measurement to measure the position of a particle. Intuitively that is fairly obvious, but it does mean there are lots of possible results, because the particle could be anywhere. So then you have to give the probability of finding it in each location. But if I have a 0 and a 1 there are only two possibilities. What are the odds of 0? What are the odds of 1? That is how we broke it down: we split up all the probabilities into 0s and 1s. So now if I want to know where a given particle is, I can quantify that by noting it in numbers that I can

⁴⁷ Quantum systems can jump from one state of excitation to another. When energy is added to a system, a jump to a higher level of excitation occurs. In a downward jump, energy is emitted from the system. See also Chapter 2.

construct form 0s and 1s. So what I am measuring is qubits.⁴⁸ That is the way in which I think about a probability wave: it is a collection of lots of qubits that all tell me with a certain probability whether they are a 0 or a 1. So, when I locate the particle, I will have read out all those qubits. So, the language of probability waves is one we mostly apply to particles moving around in atoms, because there we are interested in their position.

Sarah: So really, Schrödinger was introducing visual imagery?

Erik: Yes, it was visual imagery, Schrödinger said so himself. He called it '*Anschaulichkeit*'.⁴⁹ He had issues with the language of Heisenberg and Bohr. It was Heisenberg who described it the way we do, in terms of states. He didn't consider the particle, he only thought about the states of the atom. It was an abstract way of looking at it, and it permitted him to describe state transitions. Bohr had taught him to do it that way. Schrödinger wanted to make it more visual and came up with the wave function. I have to say, I find it a bit frustrating. I find Heisenberg's solution more elegant, with states that transition. It's more abstract. Plus, I think the idea of the wave function has confused a lot of people. It's led to questions like 'but what is the wave made of?'

Sarah (*laughing*): That is one we have asked each other! It's fascinating that it is actually an irrelevant question, because it is only visual imagery.

Ton: But the fact that the wave collapses, the atom changes its state... What is it that causes that to happen?

Erik: Yes, those are wondrous aspects of quantum physics. And I have to say that I am really not sure that we have a good answer to that. It is true that in the way we use it, there is indeed a difference between what happens if you leave it alone or if you measure it... If you measure it, you get one answer and you have been handed the actualisation of a probability.

48 Qubits are quantum bits, the quantum mechanical analogue of bits. Rather than having a value of 0 or 1, qubits can be in superposition and therefore represent both values simultaneously.

49 German for graphianness. From the word *anschauen*, which means to view.

So the wave function and its collapse turn out to be a confusing description, a further example of how language can – inadvertently – steer us away from understanding. However, realising that brings us no closer to understanding how an observation can lead to a classical measurement, to reality taking shape.

The observer in the system

Henry Stapp goes a step beyond Erik's interpretation of how reality is formed out of quantum possibilities by reserving a role for a conscious observer.

Henry: According to Von Neumann's description of quantum mechanics,⁵⁰ there are two processes at work, and the first process has two parts. First a human observer poses the question: 'Will my experience be such and such?' The second part of Process 1 is what Dirac⁵¹ called a choice on the part of 'nature'. So: we have the observer's choice of what question to ask – 'Will my experience be such and such?' – and then nature is given the job of answering the question.

Process 2 is merely the Schrödinger equation,⁵² the present situation mathematically extrapolated in a classical mechanical way to what may come later. But then if you had only Process 2, you would just generate a bigger and bigger smear of possibilities. Because of the uncertainty principle⁵³ everything just smears

50 John Von Neumann was an influential mathematician who contributed significantly to early quantum physics.

51 Paul Dirac was one of the early contributors to quantum physics. He received the 1933 Nobel Prize in Physics together with Erwin Schrödinger.

52 The equation first formulated by Schrödinger that describes how a quantum system develops over time.

53 If one of two complimentary aspects of a quantum system is measured, there is a mathematical limit to the precision with which the other can be assessed. See Lexicon.

out. So in order to tie ontology to human experience where our choices make a difference, we have Process 1 as well.

Ton: So what actually happens, during actualisation, when reality is formed?⁵⁴ I used to think of it as: there is a probability wave and then there comes an instant of actualisation and then it is not a wave or a potentiality anymore, then it *is*.

Henry: No. What *is*, is never reduced to a point. It is only reduced to some segment of what came before. Say we have a box with a ball in it, with the lid closed. Originally, we don't know where the ball is in the box. So maybe it is uniformly distributed everywhere in the box. Then we ask the question: 'Is it on the right-hand part of the box?' We ask the question, and nature gets the job of answering the question. And it will answer yes or no. If the original knowledge was that the ball was equally distributed throughout the box the probability will be one half. So the original state represents probabilities.⁵⁵

Probabilities for what, you may ask? Probabilities that the answer to any yes/no question that I might pose is determined⁵⁶. So, the density matrix is this distribution of probabilities, of possibilities. You ask the question and nature is given the task of changing the world in such a way that it corresponds to the yes answer, or changing the world in such a way that it corresponds to the no answer. Nature is the big player in this game. And we have a little bit of a task in asking a question, but nature does the real work of changing the whole world.

Ton: What happens to the other probabilities?

Henry: They are eliminated.

Ton: What happens from the instant that the answer has been given? Because then it is still a probability isn't it?

Henry: But it is a new probability.

54 Actualisation is the term Henry has used in his books to refer to the probability wave collapsing, reality taking shape. See Lexicon.

55 Henry actually used the term 'potentiality' instead of 'probability'. Changed for consistency.

56 Akin to the 0/1 choice described by Erik.

Ton: A new probability?

Henry: Well, suppose the ball is originally uniformly distributed in the box and that's what we know, that is the probability. Then I ask the question: 'Is it in the right-hand part of the box?' And then nature is going to answer yes or no. If the answer is yes, the state of probability will be reduced and now it is equally distributed on the right-hand part but it has vanished from the left: there is no probability there anymore.

Ton: So it collapses into a new probability?

Henry: In orthodox quantum theory, it collapses into one branch or the other depending on whether the answer is yes or no. So, nature is the big gorilla in the room (*laughs*). According to this theory, if nature says the answer is yes, then it has the huge capacity to obliterate the other part. In this orthodox quantum view of reality, nature is an omnipotent god. It is in absolute charge.

So Henry describes how reality is formed through a two-step process, involving the interaction between an observer and nature. Sarah & Ton asked Erik whether there is such a thing as an objective reality, or whether we should take an observer into account. He said:

I think in physics very few people are currently willing to have reality depend on who views it. However, there are certainly circumstances where we need to take it into consideration, certainly in cosmology. It relates to what we call a horizon: it means that we can only observe a system up to a certain point. Black holes have a horizon, but so does cosmology, we can only observe the universe up until a distant edge. Beyond that, it is invisible to us. With a horizon, there are always two perspectives, one of somebody who stays on this side and one of somebody who dares to cross it. That leads to two realities that do not necessarily have to be described the same way. And that has to do with us tending to describe reality using language derived from an *interpretation* of what we see. So, I think that when we look at the cosmos, we describe reality in a language that may be different from the

language in which it is written. It means we are interpreting, translating, and that means we *have* to take the observer's perspective into account. These are discussions that we have long since had in quantum mechanics, with Schrödinger's cat, who is simultaneously dead and alive, and whether the moon is there when you don't look at it; that sort of thing. In physics, we usually interpret that sort of forming of reality as being due to decoherence. However, on balance I think we need to recognise that there is some sort of dependence on observation.

Ton: Because the observer is part of the system?

Erik: Well, the observer is part of the system, of course. But sometimes when you ask a question, you need to take into account *who* is asking the question. In physics, it is near forbidden to place man at the centre of the universe. It has been ever since Copernicus showed that the sun is at the centre of the solar system. In cosmology, we have gone so far as to include in the cosmological principle that every point in the cosmos is equivalent, meaning that the whole cosmos is homogeneous. I think that was a huge leap. We know from quantum mechanics that the observer affects what he observes. His choice of moment to measure, for example, determines what the outcome of the measurement is. Well, that is something that needs to be taken seriously within cosmology. We need to realise that we are the central observer, that is what our cosmological horizon is telling us: we are at the centre of our universe.

Slowly, we are gaining more ground to bring these sorts of ideas into physics, simply because problems are arising from *not* recognising these points.

Reality as a process

Both the physicists in these dialogues, Henry Stapp and Erik Verlinde, recognise that there is a problem with the classical view of a physical reality with no role for the observer. Sarah & Ton asked Alex for his take on reality. This is what he said:

Well, I am very attracted to David Bohm's ideas,⁵⁷ the implicate order and the holomovement, in which reality is a universal flux, mostly outside our awareness. I like the language of reality being a 'quantum sea'. It gives rise to a neutral monist⁵⁸ picture of reality where everything is spontaneously welling up and a 'quantum foam' develops where particles are formed.

Ton: Welling up because it is possible?

Alex: Yes, because it is just possible and it happens. And so particles are being created constantly out of nothing.

Ton: So, reality is merely a possibility?

Alex: Yes.

Sarah: An expression of possibility.

Alex: Yeah, I think so.

Ton: Why do you add 'expression'?

Sarah: Well, the image of 'foam' suggests that there is something happening there. It is not just the sea where it is calm and nothing is happening. The foam suggests that it is active.

Alex: Right.

Ton: So, what is happening, what is the action then?

Alex: I think some things are being created out of nothing. That is basically what is happening. And that is what quantum stuff is: something from nothing.

Ton: Something from possibility.

Alex: From possibility, right.

Ton: So, reality is a possibility?

Alex: Well, reality is the realisation of one of many possibilities.

Ton: Probably.

⁵⁷ David Bohm was an influential theoretical physicist, who also worked in the areas of psychology and consciousness. He suggested that reality is a process, where there is continuous movement that precedes the formation of 'things' (and thoughts) that come out of and ultimately dissolve back into it. His ideas are most clearly described in his book *Wholeness and the implicate order*. The idea appears to have similarities with Erik's theory of information as the basis for reality.

⁵⁸ The philosophical idea that the physical and psychological (i.e. consciousness) are two different expressions of the same underlying (neutral) reality.

Alex: Probably, right, yes (*laughter*). But, I very much believe that reality is open-ended, going forward.

When Sarah and Ton first discussed their ideas, Ton described his sense that reality is a process as follows: Reality has a direction in which it is going and you can sense there are all sorts of possibilities. I think that is the nature of reality: possibility. It is not a fixed and determined identity. I think reality is made up of possibilities.

I think that reality is a process, a process where possibilities interact with other possibilities. If those 'other possibilities' are by any chance a conscious human being, then together they actualise into reality. No, I should say: actualise into that human being's experience that she takes to be reality. So, there is a phase transition there, from possibilities into experience. That leads to new possibilities and so on. This process is constantly going on at all levels of nature. Reality is not exclusively a human process. But because humans have different possibilities from, say, plants or animals, they are likely to actualise different experiences.

Sarah: That resembles Henry's quantum physical take on reality a lot, doesn't it?

Ton: Yes. Quantum physics describes that there is not one objective material reality but rather probable states, possibilities. So, whenever we talk about matter and objects as the fundamental stuff of reality, we are thinking very classically. Quantum physics shows that things are not material *a priori*, not even an atom. It is like Heisenberg said:

'If one wants to give an accurate description of the elementary particle – and here the emphasis is on the word "accurate" – the only thing which can be written down is a probability function. [...] It is a possibility, or a tendency, towards being.'⁵⁹

59 In his 1962 book *Physics and Philosophy*.

An 'observer' can perform a 'measurement', which produces an experience. You know, like a scientist measuring some quality of something and the experience is one of 'knowledge'. But this same process is going on in everyday life when you interact with the world around you. Your measurements will be more like sensing hunger and like feeling scared or happy. Or checking the balance on your bank account. Your observations are experiences. In quantum physics, the observer is a set of probabilities himself, just like everything else in this world. So, an observation is an interaction of possibilities with other possibilities and results merely in new possibilities. The experience in the observer's mind is not definitive. It is at best a statement with a high probability. Such a view of reality is much more fluid, not as fixed and dualist as the classical paradigm.

Let's face it, the above sounds far-fetched. For one thing, if reality is merely possibilities interacting with other possibilities, why is it not completely random? Why do we experience it as a continuous stream of events? Chapter 6 takes on this topic. First though, Chapter 5 addresses cause and effect, the classical way we view the connections between events.