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Lone voices special: At play in the multiverse

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- Amanda Gefter

*Note: We asked you for your questions for **David Deutsch**, but this has now closed. His answers to the best questions will appear on our website on 21 December 2006, on this page.*

In 1985, **David Deutsch** turned physics upside down by describing a universal quantum computer, pioneering the field of quantum information science. He explains to **Amanda Gefter** how this relates to notions of truth and reality in our universe - and even outside it

When you published your original paper on quantum computation, what was the general reaction?

I was expecting many people to be shocked and to say that no fundamentally new mode of computation can possibly exist, or it can't work, or there's this flaw you haven't noticed - but I got no reaction like that at all. The immediate reactions were either, yeah that's right, well done, or more usually to just ignore it altogether. People didn't take it on board as a new way of thinking. It took several years before the physics community began to work on quantum computation. There were a handful of people who saw the importance right away but the field didn't begin until several years later.

What motivated you to begin working on quantum computation?

It was a desire to understand the foundations of quantum theory, of physics, of everything. The foundations of one field tend to overlap with the foundations of others. Quantum computation, for instance, has implications not only for the foundations of quantum theory but also the foundations of physics in general, and mathematics and philosophy.

Why do you think the many-worlds interpretation of quantum mechanics, of which you are a proponent, is still only a minority view among physicists?

I don't know. I suspect it is related to a more general anti-rational phenomenon that was present in nearly all 20th-century philosophies, especially logical positivism, and reverberated into other fields. This was intended to be a retreat from metaphysics, which many philosophers considered meaningless, but really it was a retreat from reality and explanation. In physics, it took the form of deciding as a matter of principle that science is not about discovering how the world really is, but instead must confine itself to predicting the outcomes of observations. When quantum mechanics came along it required a drastic revision of people's conception of the world. Many physicists responded by denying that physics is about the world at all, only about what we see.

Logical positivism is a form of solipsism. If you say physics is only about predicting the outcomes of experiments, you can only really say it's about experiments that you personally do, because to you any other person is just another thing you're observing. But solipsism is a dead-end philosophy and when it comes to science it's a poison. It doesn't allow further progress from existing theories, and that's why I think applications of quantum theory, particularly quantum computation, were overlooked for decades. You could say people didn't really think the theory was true because they had rejected the idea of truth in science. Truth in science must mean correspondence to reality, or it means nothing.

How does quantum computation shed light on the existence of many worlds?

Say we decide to factorise a 10,000-digit integer, the product of two very large primes. That number cannot be expressed as a product of factors by any conceivable classical computer. Even if you took all the matter in the observable universe and turned it into a computer and then ran that computer for the age of the universe, it wouldn't come close to scratching the surface of factorising that number. But a quantum computer could factorise that easily in seconds or minutes. How can that happen?

Anyone who isn't a solipsist has to say the answer was produced by some physical process. We know there isn't enough computing power in this universe to obtain the answer, so something more is going on than what we can directly see. At that point, logically, we have already accepted the many-worlds structure. The way the quantum computer works is: the universe differentiates itself into multiple universes and each one performs a different sub-computation. The number of sub-computations is vastly more than the number of atoms in the visible universe. Then they pool their results to get the answer. Anyone who denies the existence of parallel universes has to explain how the factorisation process works.

This kind of theorising requires considerable creativity. What inspires your creativity?

It so happens that all of my creative work has come from trying to understand existing ideas better, rather than discovering new ideas altogether. Not from seeking new laws of nature or new particles - I have looked at existing theories and tried to understand them, and in some cases have come to understand them a little better than they were understood before. Quantum computers could have been discovered in the 1930s or 1950s, but people didn't take quantum theory seriously enough to understand what it is telling us about reality.

What advice would you give to a young physicist seeking to become a pioneer like you?

In fundamental physics research, progress is only made when people address problems within existing theoretical physics. A typical example is Einstein wondering how light is accommodated in the Newtonian universe. In the last few decades, many theoretical physicists have assumed that further progress can only come from looking at new mathematical models and then wondering if the models are true representations of nature. An example is string theory.

I think it's unlikely that a research programme of that kind can work. Even if you found the right mathematical object, you probably wouldn't even recognise it because you wouldn't know how it corresponds with the world. For example, if someone had invented quantum theory purely as a mathematical model, how would they ever guess that its multi-valued variables correspond with quantities that we measure with single values? After all, it assigns multiple values to observable quantities simultaneously. I would warn against expecting the answer to come from a new mathematical model. It should be the other way around: first find what you think might be the solution to a problem, then express it as a mathematical model, then test it.

Do you still come across sceptics who don't believe in the possibility of quantum computers?

Occasionally. At the beginning there were quite a few prominent physicists who thought a quantum computer couldn't be built. Today the sceptics are merely saying that this is much too hard, and it will take centuries. The prevailing view, I think, is that it will take decades to build a quantum computer. I've recently come to think that it might not take that long, perhaps as little as a decade.

Profile

David Deutsch is a professor of physics at the University of Oxford's Centre for Quantum Computation. In 1998 he received the Institute of Physics's Paul Dirac prize and medal, and in 2005 was awarded the Edge of Computation Science prize for work that extended the boundaries of the idea of computation. He is author of *The Fabric of Reality* (Penguin, 1998).

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