Deconstructing Everett's Crazy Idea

Fifty years ago, Hugh Everett had an idea so crazy it doomed his physics career. Today, Simon Saunders wonders if maybe Everett's idea is crazy enough to be true.

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In 1957, a young physics graduate student at Princeton named Hugh Everett III came up with an idea that not only purported to solve a major puzzle in quantum theory – the so-called "measurement problem" – it also threatened to overturn our whole conception of the universe.

MANY - WORLDS THEORY
Hugh Everett III

In other words, it had just about everything you could ask for in a new idea, with just one minor drawback: Almost everybody thought it was crazy.

Practically no one – apart from Everett's advisor and immediate family – took the idea seriously. Disenchanted, he left theoretical physics just as his career was getting underway. Everett died in 1982, never wavering in his conviction that he was right.

Now, some 50 years later, a number of physicists and philosophers of physics are starting to think that maybe Everett's idea, now known as the "many worlds interpretation," was not so crazy after all.

Or, maybe, it was just crazy enough to be true.

Rethinking Everett

That, at least, is the premise of the "Everett@50 Conference" to be held at Oxford University this July, with financial support from FQXi in the form of a $62,149 grant.

"In the past 15 years, the Everett interpretation has really come of age," says Oxford philosopher Simon Saunders, who is organizing the conference with fellow Oxford philosopher and Everett scholar David Wallace. "The idea is much stronger now than when Everett originally proposed it," Saunders adds. "That's why this really is a special time that, fortuitously, happens to coincide with the 50th anniversary of Everett's seminal paper."

"The evolution of thought on this idea has outpaced publications," agrees Wayne Myrvold, a philosopher at the University of Western Ontario who will be speaking at the event. "There's a lot of new stuff coming out that many people aren't aware of, which is why it's the right time to have a discussion like this."

But what exactly did Everett propose that has kept physicists and philosophers debating a half-century later?

It begins with the as-of-yet-unsolved measurement problem. This problem stems from the fact that a given quantum process, owing to the "uncertainty principle," is almost certain to have more than one possible outcome. Therefore, we cannot ascribe a single, ironclad position to a particle.

Physicists use a "wave function" developed by Erwin Schrödinger to describe the various outcomes of each event. The conventional, pragmatic view, known as the "Copenhagen interpretation" – or less politely, the "shut up and calculate" school of thought – holds that when a measurement is made, the wave function collapses, and the particle in question will be found in a particular position, rather than confined to a range of possible positions.

But a measurement is a physical interaction like any other, so why is there a different rule for measurements than for other interactions?

That's the crux of the measurement problem, which has given rise to a number of suggested solutions, though none so daring as Everett's. He proposed that the wave function never really collapses; instead, at every juncture where things can go one way or another – whether or not it is a "measurement" – the universe splits into different branches, each containing different copies of ourselves and the objects around us.

> We now have an interpretation that makes sense yet is unbelievable.
> *- Simon Saunders*

The virtue of this picture, explains Wallace, "is that it can describe the world as a whole, rather than just predict the outcomes of experiments." And that was, indeed, Everett's original intent, adds Saunders. "He wanted to apply quantum mechanics to the entire universe."

Nevertheless, the notion of an infinitely branching universe – or "multiverse," as it's sometimes called, where alternate histories are played out – was tough to swallow. For that reason, Everett's theory was almost universally ignored, except for a small group of physicists trying to apply quantum ideas to Einstein's theory of gravity and cosmology. Indeed, 20 years later, the Israeli physicist Max Jammer called Everett's landmark paper "one of the best kept secrets in this century."

Wild Hypothesis

Earlier in his career, Saunders, like most of his peers in the philosophy of physics, steered clear of Everett's wild hypothesis when approaching the measurement problem. After earning a PhD in 1989 on quantum field theory, he instead began work on "decoherence theory," which strives to explain why the various outcomes of experiments do not "interfere" with each other.

Saunders used the theory to explain why the world looks classical rather than quantum mechanical – to explain why, in other words, we only see only one outcome of an experiment rather than a whole ensemble. Saunders wrote his first paper on the subject in 1992 and was surprised when a referee commented: "Oh, it's many worlds!"

"I didn't see it that way at the time," Saunders recalls, "but I eventually realized the two views are equivalent. Even so, I refrained from using the term 'many worlds' until the late-1990s, at which point I was ready and willing to confront the incredulity of this notion head-on."

The mathematical methods used by Saunders – called "decoherent histories" – had only just been developed by the Nobel Prize-winning physicist Murray Gell-Mann and other investigators. The methods provided a strong theoretical indication that Everett might have been on the right track after all. This view was bolstered by another piece of the puzzle, sometimes called the "probability problem," which fell into place in the late-1990s.

The probability problem states that if you subscribe to the Everett view, and believe that every outcome of a quantum process is invariably realized – and you know everything there is to know about those outcomes – it is no longer meaningful to talk of the "probability" of an event, since every event that can possibly occur does occur in a way that is perfectly predictable.

RETHINKING EVERETT@50
Simon Saunders

But if probabilities drop out of this picture entirely, so too does most of the evidence we have that quantum mechanics is correct. If taken to the logical extreme, this view would undermine the very theory it purports to explain.

Oxford physicist David Deutsch, with Wallace, found a way out of this dilemma: Even though the branching process is guaranteed to occur in an Everett universe, the odds for the outcomes of an individual measurement – the odds for how you should bet on the results of that experiment – still follow the usual laws of probability.

Progress on the probability front, combined with advances on decoherence, "have given new legs to the Everett interpretation and have brought it closer to becoming a defensible view," says Myrvold, who still classifies himself as a skeptic. "No matter what your opinion, everyone involved in this agrees that the ideas have evolved."

Everett's Peak

Now that Everett's idea is on firmer footing, Saunders would like to see the Oxford conference "bring things to a head. We'll get the chief proponents and chief critics together and ask: Does this approach deliver? And can we actually reach a conclusion about this?"

Wallace has more modest expectations for the event. "I don't share Simon's optimism that we might settle the debate," he admits. "This is not the kind of thing that one settles suddenly or even in a year. But the debate hasn't been deadlocked for decades either. There has been movement, and the conference could further catalyze that movement."

Even if Everett was correct all along, one big question still looms, says Saunders: "Can we live with this idea of a branching universe?"

Saunders cannot deny the irony of the situation. After all these years, he says, "we now have an interpretation that makes sense yet is unbelievable." But in the end, what we find unbelievable may be immaterial, he notes, "because our intuitions are really quite parochial and unlikely to extend to the unfamiliar realms of the very large and very small."

It's quite possible that a new picture of fundamental reality may emerge from a long-sought unified theory of all of physics – one that succeeds in combining the quantum theory of all the forces, including gravity. "Perhaps it will tell us a different story, and that story may be even weirder," says Saunders. "But I'm concerned with the theory we have now. And so far, Everett has offered the only realist interpretation of quantum mechanics. While I can't say whether I believe in it or not, I do believe his theory is internally consistent. If the conference proves me wrong, fine; I'll work on trying to change quantum mechanics instead."

Or as Hilary Greaves, an Everett specialist at Rutgers University speaking at the conference puts it: "When trying to resolve the puzzles of quantum mechanics, the goal at the end of the day is not to be able to sleep better at night."