Quantum physics is 'spooky'

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The idea of parallel universes has been a staple of science fiction for many years. Movies, books and TV programs like "Fringe" and "Counterpart" have focused on this theme. In these storylines, the key characters meet their "selves" from the other world.

You may not realize it, but there is some scientific support for this bizarre idea. It comes out of the Many-worlds Interpretation of quantum physics that is gaining support among numerous physicists. More about this later.

What physicists do for a living is to observe what is going on in nature and develop predictive mathematical descriptions of those behaviors. They can then show how those behaviors will change as conditions change. In the early part of the 20th century, quantum physics evolved using this approach. It happened when physicists found that classical physics couldn't explain what they saw when they were working with very small particles, like electrons.

The mathematical descriptions that those physicists developed to characterize electrons' behaviors were very different from the laws of classical physics. The result is that the more we explore the implications of quantum physics in our reality, the weirder and more mysterious it seems.

You may not recognize it, but quantum physics has had a major impact on our lifestyles. Many of the advanced technology products we use today, like computer chips and lasers, have resulted from our understanding of quantum physics. And now we are on the verge of dramatically increasing our computer power with a revolutionary approach that depends even more directly on quantum properties.

Qubits, instead of bits, are the fundamental building blocks of a quantum computer. One of the quantum properties used in qubits is called "superposition." Instead of just a one or a zero, as the case with the bits on a computer chip, a qubit can be in multiple states at the same time. It's hard to believe, but a qubit can be both a one and zero simultaneously! An analogy to the idea of quantum superposition is when you pluck two strings of a guitar at the same time. The sound waves you hear are the combination of the two sounds, or, what is termed, a superposition of the two notes.

How is the phenomena of superposition even possible in the qubit? It is precisely because quantum systems, like electrons, behave as waves, similar to the soundwave in superposition of the two notes coming from the guitar. In fact, an electron's normal state is a wave in superposition of all its possible properties.

Electrons behave as waves, that is, until physicists observe them during an experiment. Then the electrons suddenly change and behave like particles. Yes, that's right. An electron is a wave, except when it is observed by a human. The electron seems to know it is being watched and the wave function, which describes its normal behavior, collapses, and the electron then acts like a particle. Now, that is bizarre. This understanding of quantum physics is called the Copenhagen Interpretation.

Just as strange is the quantum phenomena of entanglement. Two quantum systems, like those found in a qubit, can interact and become entangled. That is, they are inextricably linked in perfect unison. A change in one quantum system results in an instantaneous, related change in the other. But, even more mystifying is that they continue to be linked in this way no matter how far they are separated, even as far apart as opposite ends of the universe!

This observation really bothered one of the most famous physicists of all time, Albert Einstein, creator of the Theory of Relativity. Einstein is also one of the founders of quantum physics. In fact, his only Nobel Prize was for quantum physics, not relativity. What bothered Einstein was a conflict between the findings of the two fields of relativity and quantum physics.

One of the major results of his relativity work was to show that the speed of light is the speed limit for anything in the universe. This is approximately 186 thousand miles per second. At the speed of light, it would take 93 billion years for the two entangled particles at opposite ends of the universe to communicate with each other! Yet, they do, instantaneously! As a result, Einstein termed entanglement to be "spukhaften fernwirkung" or "spooky action at a distance."

Perhaps the spookiest revelation of quantum physics is one that has been growing in acceptance by many physicists. It is called the Many-worlds Interpretation.

Back in 1957, a young graduate student named Hugh Everett objected in his doctoral thesis to the Copenhagen Interpretation. Everett felt that the idea of the quantum system's wave collapsing was artificial. His alternative explanation was very simple and straightforward relative to the mathematics. He assumed that the whole universe, and everything in it, including us, is a wave in superposition, and that the wavefunction is real and doesn't collapse.

The implication of this interpretation is that all possible outcomes of any event are in superposition within the universal wavefunction. And, that all outcomes are physically realized, including us in them, in one of the many "worlds" or universes.

To the observer in each universe, it just seems that the wave function collapsed because they are not aware of the other worlds. It is truly astonishing, to think that there is more than just the universe we know, but that is the implication of the mathematics!

The idea of many parallel worlds has been used by numerous writers of science fiction where they explored the theme of meeting the person that is "yourself" from another world. In one sense, the Many-worlds Interpretation of quantum physics supports this science fiction view since it provides a scientific rationale for parallel universes. But, the scientific formulation also does not allow the worlds to interact, so rest assured, in real life you'll never meet any of your other selves.

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