Does probability come from quantum physics?

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(Phys.org)—Ever since Austrian scientist Erwin Schrodinger put his unfortunate cat in a box, his fellow physicists have been using something called quantum theory to explain and understand the nature of waves and particles.

But a new paper by physics professor Andreas Albrecht and graduate student Dan Phillips at the University of California, Davis, makes the case that these quantum fluctuations actually are responsible for the probability of all actions, with far-reaching implications for theories of the universe.

Quantum theory is a branch of theoretical physics that strives to understand and predict the properties and behavior of atoms and particles. Without it, we would not be able to build transistors and computers, for example. One aspect of the theory is that the precise properties of a particle are not determined until you observe them and "collapse the wave function" in physics parlance.

Schrodinger's famous thought experiment extends this idea to our scale. A cat is trapped in a box with a vial of poison that is released when a radioactive atom randomly decays. You cannot tell if the cat is alive or dead without opening the box. Schrodinger argued that until you open the box and look inside, the cat is neither alive nor dead but in an indeterminate state.

For many people, that is a tough concept to accept. But Albrecht says that, as a theoretical physicist, he concluded some years ago that this is how probability works at all scales, although until recently, he did not see it as something with a crucial impact on research. That changed with a 2009 paper by Don Page at the University of Alberta, Canada.

"I realized that how we think about quantum fluctuations and probability affects how we think about our theories of the universe," said Albrecht, a theoretical cosmologist.

One of the consequences of quantum fluctuations is that every collapsing wave function spits out different realities: one where the cat lives and one where it dies, for example. Reality as we experience it picks its way through this near-infinity of possible alternatives. Multiple universes could be embedded in a vast "multiverse" like so many pockets on a pool table.

There are basically two ways theorists have tried to approach the problem of adapting quantum physics to the "real world," Albrecht said: You can accept it and the reality of many worlds or multiple universes, or you can assume that there is something wrong or missing from the theory.

Albrecht falls firmly in the first camp.

"Our theories of cosmology say that quantum physics works across the universe," he said. For example, quantum fluctuations in the early universe explain why galaxies form as they did—a prediction that can be confirmed with direct observations.

The problem with multiple universes, Albrecht said, is that it if there are a huge number of different pocket universes, it becomes very hard to get simple answers to questions from quantum physics, such as the mass of a neutrino, an electrically neutral subatomic particle.

"Don Page showed that the quantum rules of probability simply cannot answer key questions in a large multiverse where we are not sure in which pocket universe we actually reside," Albrecht said.

One answer to this problem has been to add a new ingredient to the theory: a set of numbers that tells us the probability that we are in each pocket universe. This information can be combined with the quantum theory, and you can get your math (and your calculation of the mass of a neutrino) back on track.

Not so fast, say Albrecht and Phillips. While the probabilities assigned to each pocket universe may seem like just more of the usual thing, they are in fact a radical departure from everyday uses of probabilities because, unlike any other application of probability, these have already been shown to have no basis in the quantum theory.

"If all probability is really quantum theory, then it can't be done," Albrecht said. "Pocket universes are much, much more of a departure from current theory than people had assumed."

The paper is currently posted on the ArXiv.org preprint server and submitted for publication and has already stimulated considerable discussion, Albrecht said.

"It forces us to think about the different kinds of probability, which often get confused, and perhaps can help draw a line between them," he said.

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