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In his June 2022 Quick Study (page 62), David Mermin argues that “the quantum state of a system expresses only the belief of the particular physicist who assigns it to the system.” Applying that to quantum measurements, he finds that “the acquisition of further information by that physicist . . . can lead to an abrupt change in those probabilities and thus to an updating of the quantum state that the physicist uses to represent them. There is no quantum measurement problem.”

But wavefunctions have been collapsing ever since the Big Bang, with no assistance from physicists. An apparatus’s display of a measurement outcome occurs even if the experimenters happen to be out of the room. When a cosmic-ray proton strikes a sand grain on Mars and moves the grain, a quantum measurement occurs and the proton’s wavefunction collapses regardless of the absence of humans.

Roger Carpenter and Andrew Anderson of the University of Cambridge performed a “Schrödinger’s cat” experiment that demolishes Mermin’s interpretation. Instead of connecting a Geiger counter to a cat-killing device, they mercifully connected it to a hammer that would fall without harm. Their strategy was to split information about the experimental result between two observers in such a way that neither observer can know the outcome. The observers learn the outcome later by sharing their information. The question is then, Did the hammer fall at the time of the experiment or later, when the observers became conscious of the outcome? The result: The hammer fell when the nucleus decayed, not later when the observers became conscious of the outcome. I think nearly all physicists would have predicted that. My hat is off to Carpenter and Anderson, who reported it with a straight face.[1]

Humans and their consciousness have nothing to do with quantum physics. Photons, electrons, and the like, as well as their states, are real configurations of fields that have existed throughout the universe since the Big Bang.[2]

Nevertheless, I agree with Mermin’s title: There is no quantum measurement problem, because quantum physics, with no special interpretation and without a collapse postulate, logically implies that superpositions collapse nonlocally to a single definite outcome.[3]

References

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Sean Carroll’s July Quick Study, “Addressing the quantum measurement problem” (page 62), brings up the following question: Does the wavefunction still obey the Schrödinger equation when a measurement is made? A system being measured (or interacting with its environment in any other way) is actually a subsystem, and a subsystem is properly described by a reduced density matrix. The density matrix for an entire system corresponds to a wavefunction—that is, to a pure state—but the density matrix for a subsystem does not necessarily correspond to a wavefunction. The reduced density matrix of a subsystem may correspond to an impure state, also called a mixture or an incoherent combination,[1] which does not have well-defined pure-state content.[2] In the words of Kurt Gottfried and Tung-Mow Yan, “systems in the real world are rarely in pure states.”[3]

The proper way to discuss a measurement is not using a wavefunction but rather a reduced density matrix. The density matrix of a pure state evolves according to the Liouville–von Neumann equation, which is equivalent to the unitary evolution of the wavefunction by the time-dependent Schrödinger equation. For a subsystem (that is, for any system except the entire universe), the reduced density matrix evolves according to the nonunitary Liouville–von Neumann equation, which has an additional contribution causing decoherence and dissipation.[4] The nature of the measurement—or, more generally, the nature of the subsystem–environment interaction—selects a preferred basis, called the pointer basis, and the subsystem decoheres into an effectively classical mixture in the pointer basis. (See the article by Wojciech Zurek, Physics Today, October 1991, page 36.)

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Among Art Hobson’s and Gregory Derry’s letters and Sean Carroll’s July Quick Study (page 62), only Derry’s letter addresses the point I was trying to make in my June Quick Study (page 62): Viewing probabilities as personal judgments eliminates the quantum measurement problem and enables one to make better sense of quantum mechanics.

Hobson’s letter expounds his own realistic view of quantum states and their collapse. It belongs with the three examples I mention that eliminate the physicist from the story.

Carroll takes what I write about the consequences of a personalist interpretation of *probability* to be an example of an epistemic interpretation of *quantum mechanics.* That misses my point.

In 1926 Max Born noted that the content of quantum states was the probabilities that they enabled one to calculate. It is strange that after thus elevating probability to a new and foundational role, no physicists then or for the next