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LETTERS TO THE EDITORS

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Einstein's Moon

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Abstract. An account of the subjective elements of quantum mechanics or of whether, as Einstein famously asked, the Moon exists when nobody is looking at it.

Albert Einstein was not very happy with quantum theory, for a very good reason. Quantum theory is probabilistic at the fundamental level. Well, you may ask, what can be so wrong about the theory being probabilistic? Science is based on causality — that is, for every result, there is a cause. If the theory is probabilistic, it means the result appears to happen without a definite cause. This seems to be problematic as far as causality is concerned (see monographs [1, 2] for a review).

Moreover, this probabilistic nature of quantum theory shows up when there is a measurement or observation. Again, what is the big deal with a theory involving observation? Is science not all about experiments and observations? In the case of quantum theory, the problem is that the observation often changes the status of the observed physical system. In other words, subjectivity is an essential element of quantum theory. This was something Einstein, and many other people, could not accept. They thought that science should provide a consistent truth about an objective reality rather than something that varies depending on a subjective perspective. This sounds very reasonable. Or does it?

Experiments or observations form the basis of science. Although we often think science provides objective laws governing physical systems, in fact, it yields the rules about the way we observe physical systems. This was true even before quantum theory, when distinction was not necessary to improve predictability; it only added an extra burden. However, with the development of quantum theory at the beginning of the 20th century, the subjective aspect of science finally began to emerge, and it started to matter, even in terms of actual predictability. In other words, quantum theory started to reach the ultimate limit of science, as such — subjectivity.

The idea of subjectivity is nothing new. Philosophers have been talking about it for centuries. Rene Descartes argued that at least subjective thought itself was certain to exist, which he expressed in the well-known statement "I think, therefore I am." Even in the 20th century, many philosophers discussed the subjective nature of existence itself. However, is it possible to argue this scientifically rather than philosophically? Is it possible to write down a rigorous and correct mathematical equation and show that existence is indeed subjective?

In paper [3], it was shown that it is not possible to separate the observer from the observed entity using quantum theory. That is, physical systems, including atoms, the Moon, or the whole Universe, do not exist separately from my own existence. However, was the argument scientific? Was it mathematically rigorous and precise? The great power of quantum theory lies in its rigor and exactness. That is, a state vector, a mathematical representation of the physical system, is a full and exact description. What comes next is even better. When observing the state vector, one needs to be in a certain reference frame, called an observable in quantum theory. The amazing part is that this reference frame is also full and exact, just like the state vector. Okay, one may argue, you can represent the physical system and the reference frame of the observer exactly, but this does not mean the Universe is subjective.

When you have this exact representation for the physical system and the observer, there is symmetry between the observer and the observed entity. Consider a rotational symmetry. That is, if the system were rotated clockwise or if you were rotated counterclockwise, you would observe exactly the same thing on both occasions. The symmetry between the object and the observer explains the phenomenon; it is called the Schrödinger and the Heisenberg picture in quantum theory. Why does this prove the Universe is subjective?

We experience some very strange phenomenon where this symmetry between the object and the observer breaks down. This phenomenon is consciousness! In consciousness, one experiences the observation of one's own mental state, sometimes called the capacity to realize or reflexive self-consciousness. This is unique. The person is both the observer and the very object that is being observed. Because of consciousness, symmetry, established on a faithful and strict mathematical representation of the object and the observer, is no longer valid. In other words, one cannot separate the object from the observer. If the Universe is the object that is being observed, the Universe has to be subjective as well.

Einstein once asked his young friend Abraham Pais if the Moon existed only when someone was looking at it [4]. Does the Moon, indeed, exist only when I observe it? If we assume that the Moon obeys quantum theory and the unique property of consciousness, as strange and counterintuitive as it may seem, the Moon may not exist separately from my own existence.

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