

DOES THE MOON EXIST ONLY WHEN SOMEONE IS LOOKING AT IT?

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One of Einstein's young friends, Abraham Pais, reports that Einstein once asked him if he really believed that the moon existed only if he looked at it.

Einstein himself had no doubts as to the answer. In his view the commonsense belief is correct. The moon *does* exist in objective reality whether or not anyone is observing it.

So why did he ask the question?

He did so because he had long disagreed with a lot of the most important and influential physicists of his time, about the *interpretation* of that area of physics known as quantum physics that deals with the behaviour of objects in the microphysical, subatomic, world. Many of these physicists were committed to an interpretation from which it follows that *nothing* - the moon included - exists unless it is being observed. Einstein wanted to know whether Pais was on his side or theirs.

REALISM VERSUS ANTIREALISM

Einstein himself was a realist. He believed that there is a real world that exists independently of the human mind.

Many quantum physicists were, and still are, antirealists. Many believed, and many still believe, that there is no such thing as an objective reality.

Following, often unknowingly, in the footsteps of certain influential "Idealist" philosophers like the eighteenth century philosopher, Bishop Berkeley, antirealists hold that what we call "reality" is merely a mental construct and hence that things like the moon exist only in so far as human beings are observing them.

Among these idealist-minded physicists were some of the greatest physicists of the 20th century. Two of them - Niels Bohr and Werner Heisenberg - had contributed, along with Max Planck and Einstein himself, to establishing the foundations of quantum physics

Einstein agreed with Bohr and Heisenberg about the experimental data that had been obtained when they had tried to carry out simultaneous measurements of the position and momentum of subatomic particles like electrons. It simply couldn't be done, for reasons having to do with Planck's discovery that energy comes in multiples of little packets called "quanta".

But what was the *significance* of the fact that it can't be done?

THE ANTIREALIST INTERPRETATION.

Bohr and Heisenberg gave an explanation that has come to be known as the "Copenhagen Interpretation" according to which each of the following claims is true:

Antirealist claim 1:

Physical theories should restrict themselves to what can be observed or in some way measured.

In Heisenberg's words:

The hope that new experiments will lead us back to objective events in time and space is about as well-founded as the hope of discovering the end of the world in the unexplored regions of the Antarctic.

Some physicists would prefer to come back to the idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist independently of whether we observe them. This however is impossible.

As a later physicist, David Bohm, put it when describing the Copenhagen interpretation (with which he disagreed):

In the usual [Copenhagen] interpretation of the quantum theory, *an atom has no properties at all when it is not observed*. Indeed, one may say that its only mode of being is to be observed; for the notion of an atom existing with uniquely definable properties of its own even when it is not interacting with a piece of observing apparatus, is meaningless within the framework of this point of view.

Antirealist claim 2:

It is "meaningless" to talk about an object existing except when it is being measured.

Thus Heisenberg claimed:

The concept of the path of an electron between two successive measurements is meaningless.

Likewise another physicist, Percy Bridgman, put it:

Since an object never occurs naked but always in conjunction with an instrument of measurement or the means whereby we

obtain knowledge of it, the concept of 'object' as something in and of itself, is an illegitimate one.

Max Born was fully aware that this claim derived from a *philosophical* decision to adopt a certain methodological principle for the *interpretation* of experimental results:

Modern physics has achieved its greatest successes by applying the methodological principle that concepts which refer to distinctions beyond possible experience have no physical meaning and ought to be eliminated.

Antirealist claim 3:

Since measurements can only be carried out by conscious human beings, and objects don't exist except when they are being measured, objects can't exist independently of human consciousness.

This claim was made by early defenders of the Copenhagen interpretation and is still being made by a number of its current supporters.

Thus, in his 1979 *Scientific American* article, Bernard d'Espagnat wrote:

The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with quantum mechanics and with facts established by experience.

And the contemporary physicist, David Mermin, explicitly contradicted Einstein when, in 1981, he wrote:

The moon is *not* there when nobody looks.

In Einstein's view, none of these antirealist claims can validly be inferred from the data yielded by experiments in the domain of quantum physics. On the contrary, he claimed, they can be inferred only if one adopts certain indefensible philosophical principles for the *interpretation* of the data. His antirealist opponents, he would claim, may have done good physics, but have been lured into doing bad philosophy.

THE REALIST INTERPRETATION.

Einstein, as a realist, rejected each of the above claims and replaced them with ones of his own.

Realist claim 1:

An objective reality exists whether or not human beings exist or know its features.

Philosophers refer to this claim as "metaphysical realism". According to it, something can exist even if we human beings do not know that it exists. The question whether something actually *exists* in objective reality is said to be an "ontological" question. The question whether something is *known* or *perceived to exist* is said to be an "epistemological" question.

Einstein held that it was a grave mistake to confuse ontological questions with epistemological ones.

Thus he wrote:

[the scientist] seeks to describe a world independent of the acts of perception.

Realist claim 2:

It is the business of physics to give true descriptions of objectively existing objects such as the moon.

Philosophers refer to this sort of claim as "scientific realism".

According to Einstein, the whole purpose of science is to get behind the phenomena of experimental data and their mathematical description to the real world that underlies them. As he put it, "Reality is the business of physics". He believed, to the end, that the goal of science was to discover the way the world really is as opposed to our perceptions and conceptions of it, and that orthodox quantum theory had not only failed to achieve such a goal but had prematurely abandoned any such quest.

In physics, as he saw it:

everything is to be reduced to conceptual objects situated in space-time and to strict relations which hold for these objects. In this description, nothing appears which refers to empirical knowledge about these objects. A spatial position (relative to the co-ordinate system used) is attributed to, say, the moon at any definite time, quite independently of the question whether observations of this position are made or not. This kind of description is meant if one speaks of the physical description of a 'real external world' . . .

It is clear that, in adhering to both metaphysical and scientific realism, Einstein was also adopting a third kind of realism, sometimes called "semantic realism", i.e., the belief that a statement of any sort whatever (including a

statement of physics) is true if, and only if, reality is as the statement says it is.

This realist theory of truth is opposed to certain other theories of truth, for example to the so-called "pragmatist" or "instrumentalist" theory according to which a statement is accepted as true if and only if it is useful to accept it. Many of Einstein's antirealist opponents seem to have adopted a pragmatist theory. They held that physical theories, such as those of quantum mechanics, are to be regarded as true just in so far as the mathematical description of quantum phenomena provides a useful *instrument* for prediction and explanation. Niels Bohr, in particular, seems to have thought of quantum theory in this sort of way when he wrote: "*There is no quantum world. There is only an abstract [mathematical] description.*"

Realist claim 3:

Microphysical particles, like atoms and their constituents, and macrophysical objects, like the moon, may exist whether or not they are being observed.

To repeat the third sentence in the passage just quoted, Einstein held that, in physics . . .

A spatial position (relative to the co-ordinate system used) is attributed to, say, the moon at any definite time, quite independently of the question whether observations of this position are made or not.

Einstein's realism (metaphysical, scientific, and semantic) was, and still is, shared by a number of other great physicists. Among them can be listed: Max Planck, Erwin Schrodinger, Louis de Broglie, and - much later - David Bohm.

In Einstein's view, the antirealist beliefs of physicists who adopted the Copenhagen interpretation were akin to those of a religion that is based more on faith than on evidence. As he put it, disparagingly:

The Heisenberg-Bohr tranquilizing philosophy - or religion? - is so delicately contrived that, for the time being, it provides a gentle pillow for the true believer from which he cannot very easily be aroused. So let him lie there.

MORE ARGUMENTS FOR REALISM.

So what are we to say about antirealism in general, and about the status of the moon in particular?

Here are two philosophical arguments (neither of which seems to have been explicitly advanced by Einstein or his defenders in the physics community) for adopting a realist point of view.

1. If antirealism were correct, and nothing can meaningfully be said to exist unless it is observed by a conscious human being, then most of our commonsense beliefs and the most of science itself - such as the sciences of cosmology (to do with the Big Bang theory of the origins of the universe) and evolutionary theory (to do with the origins of the human species) - would have to be rejected.

According to both these branches of science, conscious human beings are relative newcomers on the cosmic stage and hence were not around at the time when the universe began or when we evolved from nonhuman primates. Hence, if antirealism were true, then it would follow that, prior to our existence, nothing else existed. Sciences that have to do with pre-human states of the universe would have to be rejected as false or even nonsensical. Since quantum antirealism is inconsistent with a host of other well-established truths of sciences, it should be rejected as false.

2. If antirealism were correct, and nothing can exist unless it is being observed, then objects such as the moon cannot exist unless their subatomic constituents are being observed. For it is an obvious, and unassailable, truth that a complex object cannot exist unless its simple constituents exist. And since it is clearly true that no-one is observing, or ever has observed, the subatomic particles of which the moon consists, it would follow, contrary to David Mermin, that the moon does not exist even when someone *is* looking at it. For that matter, since no-one is observing or measuring the elementary particles of which human beings consist, it would follow that *we* do not exist to make observations or measurements of anything at all. But this conclusion is inconsistent with the indisputable fact that human beings and the rest of the universe exist. Hence the antirealism interpretation of quantum mechanics should be rejected as indisputably false.

True, there are difficult problems involved in giving a correct interpretation of quantum experiments. But, if the above arguments in support of Einstein are sound, then it follows that the Copenhagen interpretation *cannot* be the correct one.