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Quantum Physics May Upend Our Macroscopic Reality In The Universe

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If a tree falls in the forest and someone is there to hear it, does it make a sound? Perhaps not.

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Once again, quantum physics is calling our concept of reality into question.

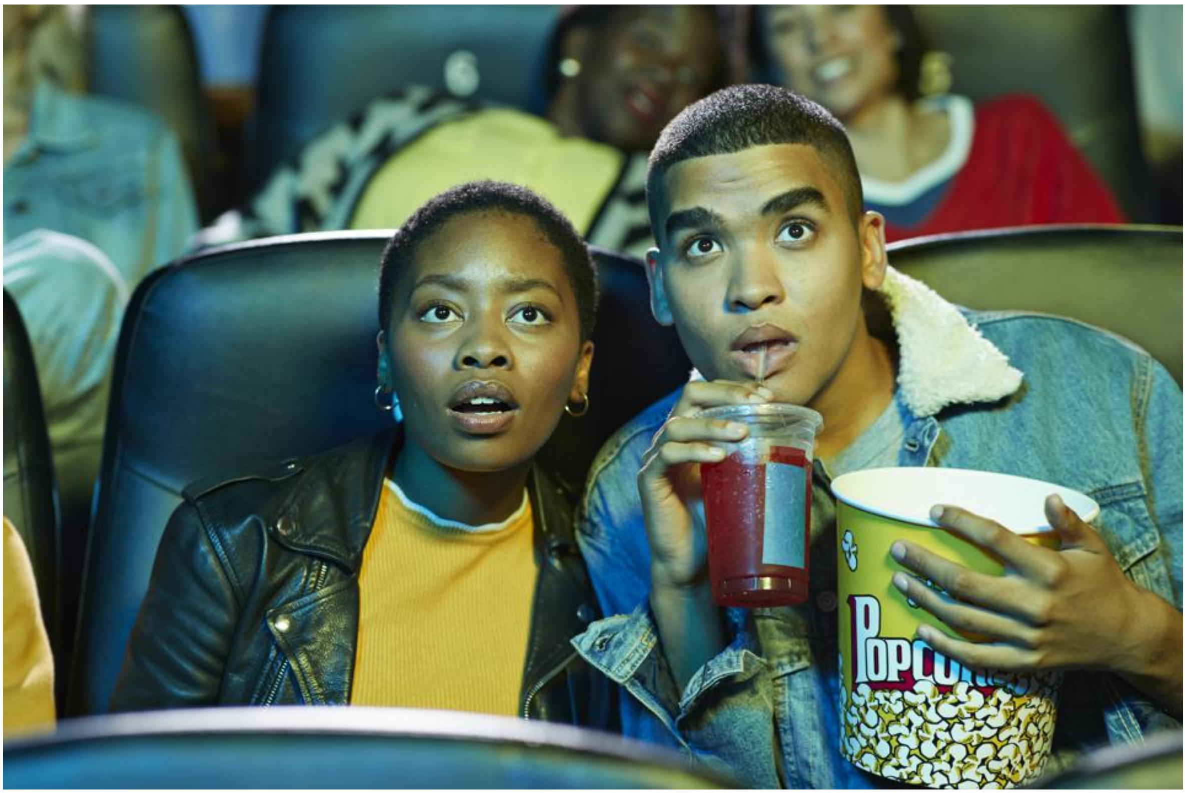
If you are familiar with quantum physics, you know that on very tiny scales, the Universe is very weird. Particles act like particles and waves at the same time. An electron may be in one location, and then suddenly in another location, without ever passing through a point between those two spots. Or even a single particle can interact with itself.

But on the macroscopic scale, things are more "normal". At least, we think. But perhaps quantum physics also affects us, as macroscopic observers. And recent research published in Nature Physics says for even macroscopic observers, quantum physics may call our reality into question.

Tenets Of Reality That Are True... Or Are They?

As macroscopic observers, we can say three things about reality.

1. If you see an event happening, it really happened.
2. You can make free choices. Particles can make "free choices" too, which are statistically probabilistic.
3. If something happens, it can't instantaneously affect something far away. Information can only travel so fast, normally governed by the universal speed limit - the speed of light.



If we observe something, we believe it really did happen. GETTY

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Let's compare these with reality on a quantum level.

1. A particle does not have a precise property until measured. For example, a particle doesn't have a precise position unless something - whether it be a person or a photon of light - "observes" it. This isn't simply that we don't *know* what the particle's position is - it is that it doesn't *have* a position - only an array of probable locations.
2. Even with measurements, there are somethings we can never know precisely. For example, we can never know a particle's position and momentum at the same time. This is known as the Heisenberg Uncertainty Principle.
3. Two particles can be entangled. This means that if you observe one particle to be, say, red, the other will also be red. Or if you observe a particle to be blue, the other will be blue. But the really trippy part - these properties are not intrinsic properties of the particles. The particles decide whether they are red or blue the instant you observe them - and somehow communicate that choice instantaneously - independent of where those particles are. This is known as Bell's Theorem.

These two realities are very different. If our normal, macroscopic world started acting in a quantum way, the world would be a very different place.

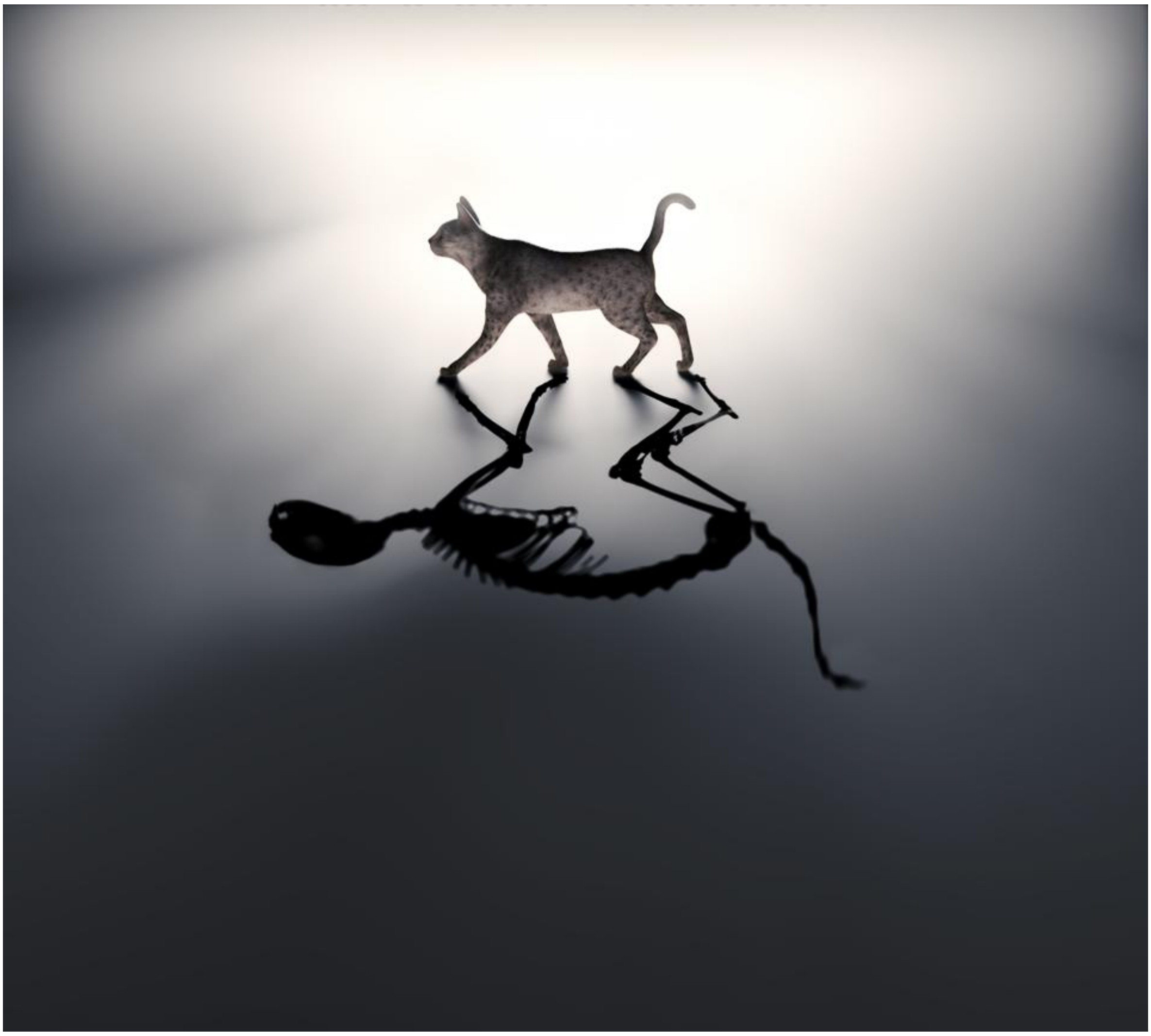
But perhaps, our world is not as clear cut as we thought it is.

Observing The Observer

Let's try to mess with our macroscopic reality a bit.

To do this, we can do a thought experiment, where the observer of the particle is also observed.

The experiment, known as Wigner's friend, goes like this. You have a scientist, let's call him Charlie, who is sealed inside a lab. He makes an observation of a particle as either red or blue. His friend, Alice, waits outside. From Alice's perspective, she doesn't know whether Charlie measured the particle as red or blue. According to her, until she opens up that lab door and asks Charlie what he saw, the particle is both red and blue at the same time. This is similar to the outcome we see in the Schrödinger's cat experiment, where a cat in a box is both alive and dead until observed.



Like Schrödinger's cat, from Alice's perspective, Charlie would have measured his particle as both ... [+] GETTY

Eugene Wigner, the physicist who came up with this thought experiment, thought this was absurd. Charlie has a consciousness - he can't be in two states at once (one where he observed the particle as red and one where he observed the particle as blue). Thus, Wigner claimed, human consciousness causes all of this uncertainty to collapse.

This makes sense to us in a macroscopic world. But what's so special about human consciousness? And why (or are) observers so special?

Extending The Experiment

This is where Wigner left off. But another version, first proposed by Časlav Brukner, was recently extended by a group of scientists at the Centre for Quantum Dynamics at Griffith University and the Department of Physics and Center for Quantum Frontiers of Research & Technology at the National Cheng Kung University.

In their version, there are two observers locked in their labs on opposite sides of the planet, Charlie and Debbie. They both observe entangled particles, say, as red or blue. Remember, if Charlie observes his particle as blue, Debbie's entangled particle must also be blue. This causes Charlie and Debbie to now be entangled with one another. Charlie and Debbie, in turn, have two observers, Alice and Bob.

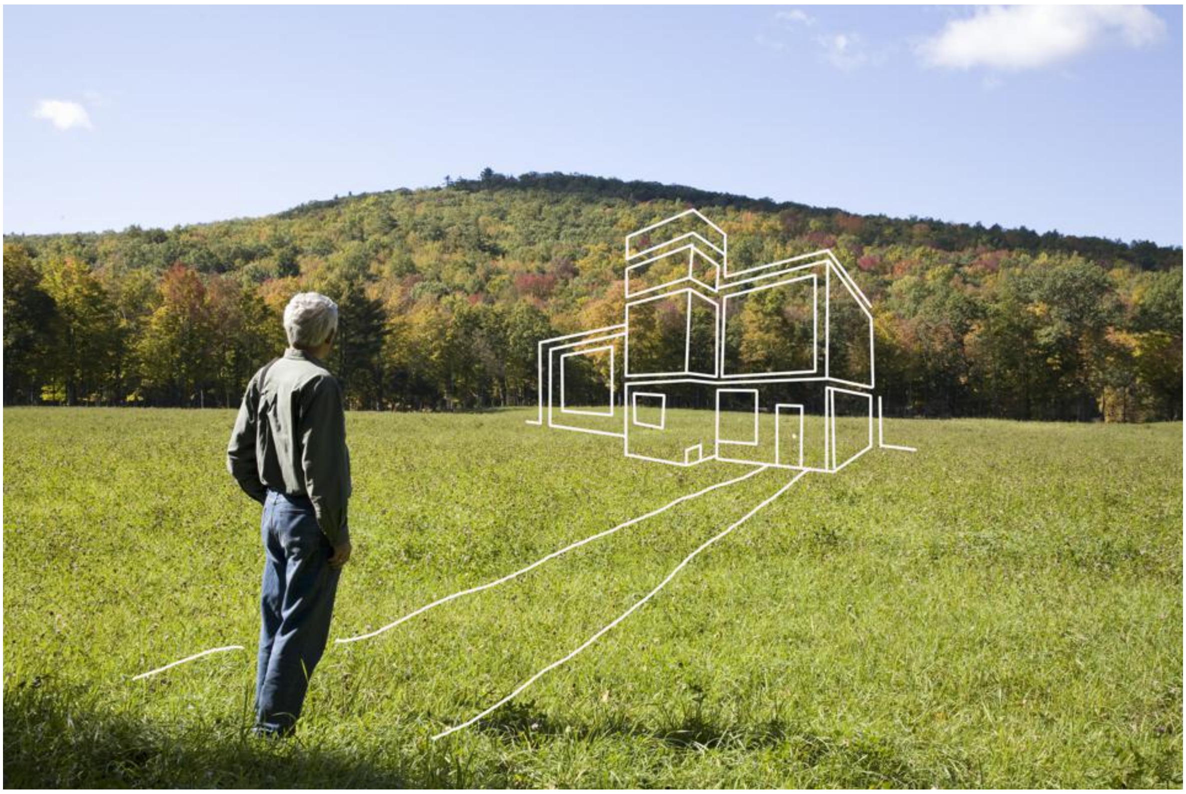
Alice and Bob then each flip a coin. If it's heads, they open the door to the lab of Charlie and Debbie and ask for the result of their experiment. If tails, they do another measurement, that will come out positive if Charlie and Debbie are entangled with their particles.

No information inside the lab should leak out at all, except if Alice and Bob open the door and ask their friends about the result of their experiment. Even Charlie and Debbie, after the experiment, can't remember the result.

At this point, let's go back to our tenets of reality and see how they relate to this experiment. Charlie and Debbie really see the particle as red or blue, and this reflects some sort of objective reality. In addition, this reality should not be dependent on the "choice" that Alice and Bob make when they flip their coin.

After thousands of realizations, the researchers found that the number of correlations that Alice and Bob see with whether Charlie or Debbie measure their particle as blue or red exceeds the amount expected if our three tenets of reality hold up.

What this means is that something strange is happening when consciousness interacts with quantum physics. Either our idea of quantum physics needs to be revised, or we don't have a full grasp on reality.



If this experiment holds for human observers, our reality may not be objectively true. GETTY

"For one, the correlations we discovered cannot be explained just by saying that physical properties don't exist until they are measured," says Dr. Eric Cavalcanti, one of the authors on the paper. "Now the absolute reality of measurement outcomes themselves is called into question."

Now, there are some limitations to this experiment. For one, Alice, Bob, Charlie, and Debbie weren't real people. However, if the same results aren't obtained with real people in some future example of this experiment, that means conscious observers really *are* special. If we do get the same results, then one of our tenets of reality must not be true. Reality for one person may not be the reality seen by another person.

In any case, this work sets the stage for how quantum physics and consciousness can come together to help us understand the true nature of reality.

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