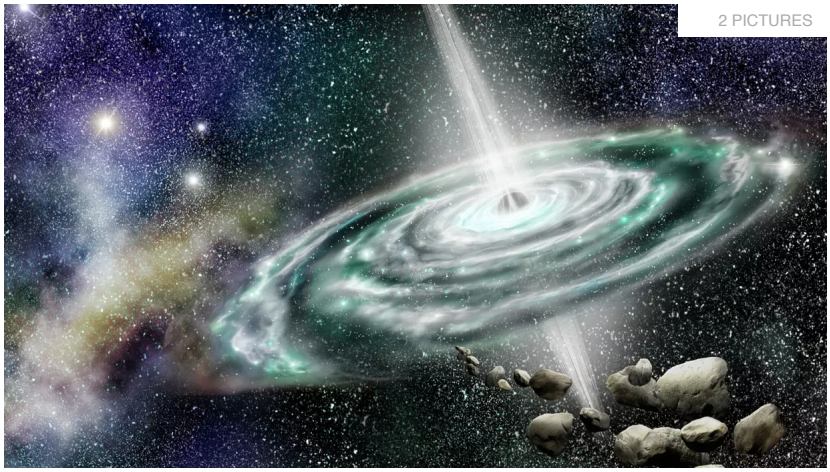
PHYSICS

Quasars may prove quantum entanglement – or a 12 billion-year-old conspiracy

Michael Irving | a day ago



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Light from distant quasars has been used as a cosmic "coin flip" to help provide the strongest evidence so far of quantum entanglement (Credit: draco-zlat/Depositphotos)

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Quantum entanglement - the idea that two particles can remain inextricably linked across vast distances - is an eerie concept that Einstein himself had trouble accepting, and yet over the past few decades it's been experimentally demonstrated time and time again. But are there other variables involved that we simply don't understand yet? To find out, MIT researchers have now performed an experiment that provides the strongest evidence so far of either quantum entanglement, or a "conspiracy" that dates back over 12 billion years.

If you were to study a pair of particles that were quantum entangled, measuring the physical properties of one particle instantaneously affects that same property of its partner, no matter how much space separates the two. Classical physics says that nothing can travel faster than the speed of light - but quantum entanglement breaks the rules by apparently allowing those particles to communicate more than 10,000 times faster.

When the phenomenon was first noticed by Einstein, who famously called it "spooky action at a distance," it was considered evidence that our understanding of quantum theory was incomplete. Einstein said "hidden variables" must be interfering, which were still to be discovered.

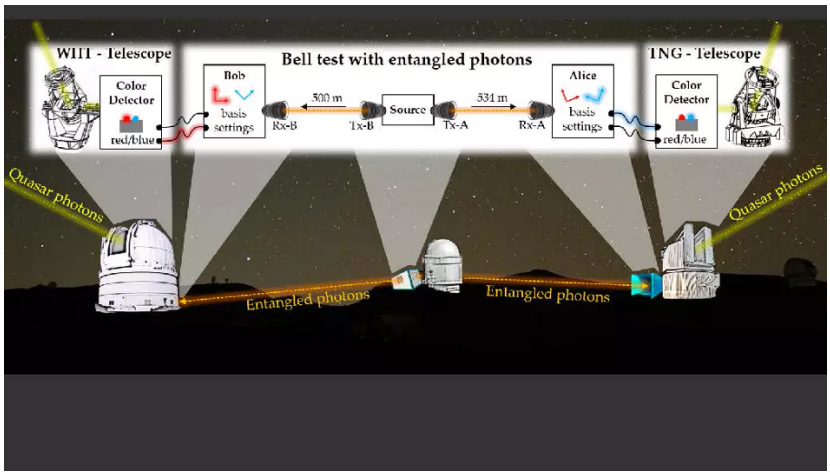
In the 1960s, physicist John Bell tried to quantify the influence of these hidden variables. If you're testing pairs of particles, Bell says, there's a certain limit where the correlations become far too regular to be mere coincidence. Any correlations higher than this limit are most likely evidence of quantum entanglement. Frustratingly though, experiments designed to test Bell's inequality could introduce loopholes, through which those hidden variables might mess with the results again.

Closing the loophole

Those loopholes can be just as spooky as quantum entanglement itself. One of the hardest to close is the "freedom-of-choice" or "free-will" loophole - basically, what if some unknown force is tampering with the researcher's decision about what to measure, making the outcome look like a correlation when it actually isn't?

One way to close that loophole is to remove the human decision from the experiment. In earlier tests, scientists used random number generators to make a split-second choice about what property was going to be measured between pairs of photons, but even this was thought to leave a gap. Local reality, after all, might not have too hard a time influencing an event just nanoseconds before it occurs.

So the MIT researchers decided on the ultimate test: What if the "decision" has already been made, billions of years before the experiment was ever conceived?



Cosmic coin flip

Let's say you're studying two rubber balls to see if they're the same. You can either check if they're the same color or the same size, and to make that decision you flip a coin to randomize it. That's essentially what the MIT researchers were doing in the latest experiment – but the coin was flipped 8 billion years ago. Hidden variables are going to have a hard time interfering with that.

The researchers beamed pairs of entangled photons in opposite directions down a tunnel, towards detectors at either end. Before the photons struck the detectors, a "coin flip" changed the angle of those detectors in order to measure a different property of the photons.

In this case, the "coin" was light from two distant quasars. The researchers used two large telescopes in the Canary Islands to monitor these incredibly bright celestial objects and make the decision. If the light of a single photon from the quasar was red, it would tilt the detector to one angle. If it was blue, it would tilt a different way.

The kicker is that one of these quasars is 7.8 billion light-years away, and the other is 12.2 billion light-years, meaning the light from them took that long to arrive here. The decision about how to measure the entangled photons was up to 12.2 billion years in the making.

"The Earth is about 4.5 billion years old, so any alternative mechanism – different from quantum mechanics – that might have produced our results by exploiting this loophole would've had to be in place long before even there was a planet Earth, let alone an MIT," says David Kaiser, co-author of the study. "So we've pushed any alternative explanations back to very early in cosmic history."

The researchers ran this same experiment twice for 15 minutes each time, using two different pairs of quasars. Overall, they measured more than 30,000 pairs of entangled particles, which showed correlations far beyond Bell's limit. The team then calculated that the chance of hidden classical variables messing with the results would be about one in a hundred billion billion.

"If some conspiracy is happening to simulate quantum mechanics by a mechanism that is actually classical, that mechanism would have had to begin its operations - somehow knowing exactly when, where, and how this experiment was going to be done - at least 7.8 billion years ago," says Alan Guth, co-author of the study. "That seems incredibly implausible, so we have very strong evidence that quantum mechanics is the right explanation."

The researchers admit that there's still an extremely tiny chance that the results came through a loophole. In the future, the team plans to run a similar test using some of the oldest light in the universe - microwave radiation left over from the Big Bang itself.

The research was published in the journal *Physical Review Letters*.

Source: MIT

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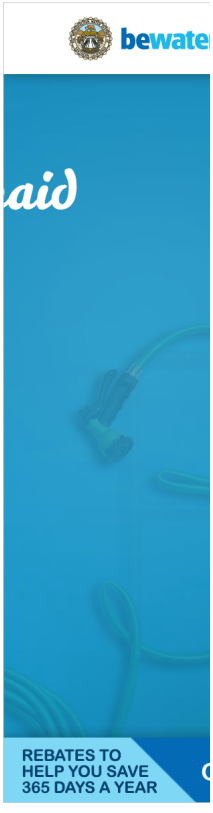

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