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Starlight test shows quantum world has been weird for 600 years

Entanglement is written in the stars
Narathip Ruska/Alamy

By **Leah Crane**

Our universe has been ruled by weirdness for at least six centuries. If the quantum effects in a new experiment aren't genuine, but are somehow caused by past meddling, then that is how long ago it must have happened – a finding that makes would-be alternatives to quantum theory even more unlikely.

Two qualities seem to describe our everyday world: realism, the idea that things have properties which don't vanish when we're not looking; and locality, which means no influence can travel faster than the speed of light.

But the quantum effects we see on tiny scales defy these descriptions. The properties of particles aren't set in stone until we measure them, and their states can be entangled – such that altering one affects the other much faster than light can travel between the two.

There are loopholes in quantum theory, though. David Kaiser at the Massachusetts Institute of Technology and his colleagues are trying to close them down – aided by starlight.

Their experiment exploits a standard test for locality: Bell's inequality. It sets a limit on how often two entangled particles can end up in the same state just by chance – without quantum mechanics or some unknown "hidden variables" to guide them.

The first step is to create a pair of entangled particles – often photons of light – then fire them off in different directions. Usually, a random number generator determines at the very last moment which property of each particle

But it's still dimly possible that some unknown influence is allowing the particles to affect each other without breaking the principle of locality. To rule this out, Kaiser and his colleagues didn't use any old random number generator to decide what to measure. After all, it's even possible that the hidden variables could be tampering with the number generation itself.

Instead, after the photons were shot towards the detectors, the researchers made a measurement of light from a randomly chosen star in the Milky Way. Its colour was what determined which photon property to measure.

"If any physical mechanism were to somehow jigger with the questions that get asked of each particle, those would have to have been put in motion at that star when it was about to emit that light that we measured," Kaiser says. Light from the closest star they used takes 600 years to reach us, so any hidden variables would have needed to be in play since then.

As in previous tests, Kaiser's team found that their photons ended up correlated far too often, violating Bell's inequality and supporting the non-local, quantum notion of reality.

Of course, this loophole can never really be closed. Maybe the outcomes of these experiments were determined by hidden variables 700 years ago, or at the birth of the universe. But Kaiser and his colleagues plan to keep using larger telescopes and more distant astronomical events to rule out the loophole as far back as they can.

"They're making alternative theories to quantum mechanics far more implausible – and they were already implausible to start with," says Krister Shalm at the National Institute of Standards and Technologies in Boulder, Colorado. "This is just going that extra step of pushing things back."

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