

# Quantum correlations do not imply instant causation

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Credit: Christina Giarmatzi, University of Queensland

A research team led by a Heriot-Watt scientist has shown that the universe is even weirder than had previously been thought.

In 2015 the universe was officially proven to be weird. After many decades of research, a series of experiments showed that distant, entangled objects can seemingly interact with each other through what

Albert Einstein famously dismissed as "Spooky action at a distance".

A new experiment by an international team led by Heriot-Watt's Dr Alessandro Fedrizzi has now found that the universe is even weirder than that: entangled objects do not cause each other to behave the way they do.

Distinguishing cause from effect comes naturally to us. Picture yourself in a room where someone is flicking a light switch. Intuition and experience lets you establish a simple causal model: the switch causes the lights to turn on and off. In this case, correlation implies causation.

If we could entangle two lights, you would see them turn on and off at random, regardless of how far apart they are, with no obvious switch and in perfect lockstep. Einstein's preferred explanation of this mysterious effect was that there must be a hidden light switch which acts as a common cause for our entangled lights.

Einstein's world view was finally proven wrong last year by groups in Vienna, Delft and Boulder. However, the search for an answer how entanglement really works continues, and one popular explanation was that entangled objects could cause each other perhaps instantaneously, ignoring the universal speed-of-light limit.

In a new experiment, Dr Fedrizzi and colleagues found that this claim is also wrong. They set up individual photons to act like entangled light bulbs and then subjected them to two tests.

In the first, they essentially flicked the [light switch](#) themselves to test their causal hypothesis. In the second, they tested a new inequality by theory collaborator Rafael Chaves, which shows that nonlocal causality can in general not explain quantum entanglement.

## 'Spooky' action

"We have spent decades to prove Einstein wrong and can now start looking into extended models of his 'spooky' action", says Dr Fedrizzi. "What we found is yet another mechanism that doesn't explain this quintessential feature of entanglement. Our results drastically narrow down the remaining explanations."

The techniques the team developed also have practical applications such as in cyber-security. They can for example be used to increase the level of trust we have into quantum encryption devices.

Their study has been published in *Science Advances*.

**More information:** M. Ringbauer et al. Experimental test of nonlocal causality, *Science Advances* (2016). [DOI: 10.1126/sciadv.1600162](https://doi.org/10.1126/sciadv.1600162)

Provided by Heriot-Watt University

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