Astronomy + Physics

Quantum entanglement in the cosmic test

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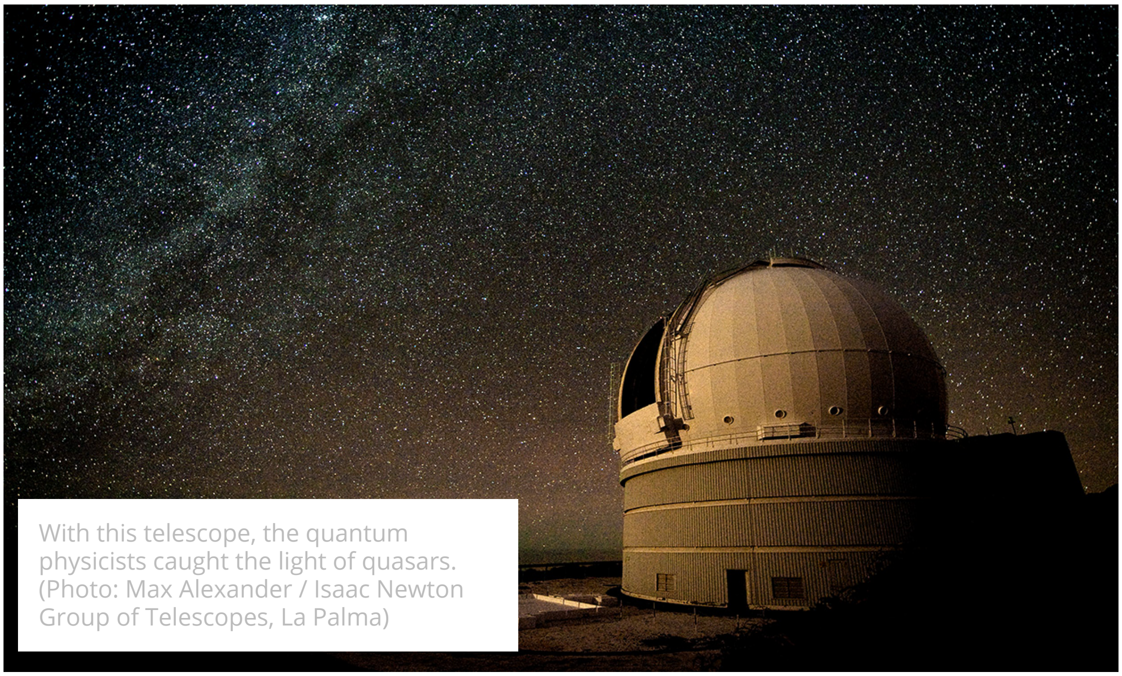

With this telescope, the quantum physicists caught the light of quasars. (Photo: Max Alexander / Isaac Newton Group of Telescopes, La Palma)

The entanglement is one of the most fascinating and important phenomena of quantum physics. Because this particle coupling can not be explained with classical physics - if quantum mechanics is right. Now researchers have subjected quantum entanglement to their most rigorous test yet, using the light of distant quasars as "cosmic random generators". Two telescopes on the Canary Island of La Palma served as receiving and measuring stations. The result: The world's first experiment of this kind has confirmed the validity of quantum mechanics.

Albert Einstein skeptically described the phenomenon of quantum physical entanglement as a "ghostly long-distance effect". No wonder, this connection of the states of particles seems almost magical. For when two particles are entangled with each other, the measurement of the state of one automatically and immediately leads to a change of state of the other - even over long distances. Although no information is exchanged between the quantum particles, their state is interdependent. This entanglement can not be reconciled with classical physics. Einstein therefore suggested that there are still unknown influences that influence such measurements. But since then, special experiments, so-called Bell tests, have already refuted this many times.

Quasars as cosmic helpers

One flaw, however, remained: all these experiments contained "loopholes" that would theoretically allow us to explain measured correlations without quantum mechanics. One of the most persistent loopholes is that of freedom-of-choice loophole: particles and measuring equipment could theoretically have been causally influenced before the experiment. The measurement result would not have come about by chance and saved Einstein's classical physics. One way to close this loophole has now been taken by Dominik Rauch from the Institute of Quantum Optics and Quantum Information (IQOQI) in Vienna and his colleagues. They used the light of two distant quasars to determine the measurement settings of their entanglement experiment.

For their experiment, the researchers generated entangled photons in a plant on the Canary Island of La Palma and then sent the coupled light particles in opposite directions. At each end of the measurement path these particles were captured by a telescope and their polarization measured. The stations used were the William Herschel Telescope and the Telescopio Nazionale Galileo. The trick here: The angle of the polarization meter on these telescopes did not choose the scientists, but a cosmic helper. Because each of these telescopes was focused on a quasar and determined the wavelength of the incoming light - a quasar was 7.8 billion light-years away, the other 12.2 billion light-years. The quasar light determined in which direction and how strongly the polarization measuring instrument was tilted during each measurement in the interlacing test. If the wavelength of the light was above a certain value, the researchers set one angle, and the other with blue light.

Entanglement confirmed

"It is the first time that billion-year-old light from our universe has been used to demonstrate quantum entanglement," explains senior author Anton Zeilinger from the IQOQI. He and his colleagues subjected this cosmic Bell test to a total of 30,000 photon pairs - and once again, quantum physics clearly proved to be incompatible with classical influences. The two telescopes registered clear correlations in the polarization state of the entangled photons. "The probability that there are hidden influences that provide an explanation of entanglement that is alternative to quantum mechanics is almost zero. The choice of the exhibition setting would have had to be made long before the formation of the earth for our experimental setup, "says Zeilinger. Because all local classical influences, Thus, the "ghostly long-distance effect" has also successfully withstood its hitherto toughest test. However, these Bell tests are not only important for basic physical research. The reliability of entanglement also plays a major role in practical applications of quantum optics. "The refutation of loopholes is very important for quantum cryptography," explains Zeilinger. "For the secure exchange of quantum encrypted information, unknown influences must be completely excluded."

Source: Dominik Rauch (Institute of Quantum Optics and Quantum Information (IQOQI), Vienna) et al., Physical Review Letters, doi: 10.1103 / PhysRevLett.121.080403

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