

Leiden physicists entangle four rotating photons

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Leiden physicists sent short ultraviolet laserpulses of two picoseconds through a crystal. This leads to the creation of four photons that are entangled in their orbital angular momentum—here depicted as red blue spirals. The rainbow colored circles illustrate the phase (color) and intensity (brightness) of the photon's cross section. Credit: Leiden Institute of Physics



For the first time, scientists have entangled four photons in their orbital angular momentum. Leiden physicists sent a laser through a crystal, thereby creating four photons with coupled 'rotation'. So far this has only been achieved with two photons. The discovery makes uncrackable secret communication of complex information possible between multiple parties. The report is forthcoming in *Physical Review Letters*.

Entanglement holds great promise for perfectly secret communication and quantum computing. If two <u>photons</u> are created simultaneously, they are counterparts—their rotation is always reversed with respect to the other. If we measure left rotation for one photon, then the other will always rotate to the right after measurement with a similar filter. This is called entanglement. Before the measurement, each photon's rotation is undetermined.

Milestone

Such rotation is a property of photons that scientists discovered in 1992 in Leiden; physicists call this orbital angular momentum. And this property has more than two values. It covers an infinitely large alphabet of information. Via rotation, it is possible to transfer much more information per photon than with a property like polarization, which contains only two possible values. In 2001, scientists managed to entangle two photons in orbital angular momentum for the first time. Now, Leiden physicist Wolfgang Löffler and his colleagues are the first to entangle four photons in this way. The discovery offers additional possibilities, like sending an uncrackable encrypted message to more than one party.

Experiment

During their successful experiment, the researchers sent short ultraviolet



laser pulses of two picoseconds through a crystal. Occasionally, this leads to the creation of four <u>entangled photons</u>. This is extremely rare, but by generating 80 million pulses per second, they managed to detect on average two so-called photon quadruplets each second. To confirm these were, indeed, entangled in <u>orbital angular momentum</u>, the team used a spatial phase modulator that converts this <u>rotation</u> back to light traveling as a plane wave. They registered this 'normal' light with single photon detectors.

More information: Observation of four-photon orbital angular momentum entanglement, B. C. Hiesmayr, M, J. A. de Dood, W. Löffler, *Physical Review Letters*, 2016. On *Arxiv*: arxiv.org/abs/1508.01480

Provided by Leiden Institute of Physics

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