Physicists create turnstile for photons

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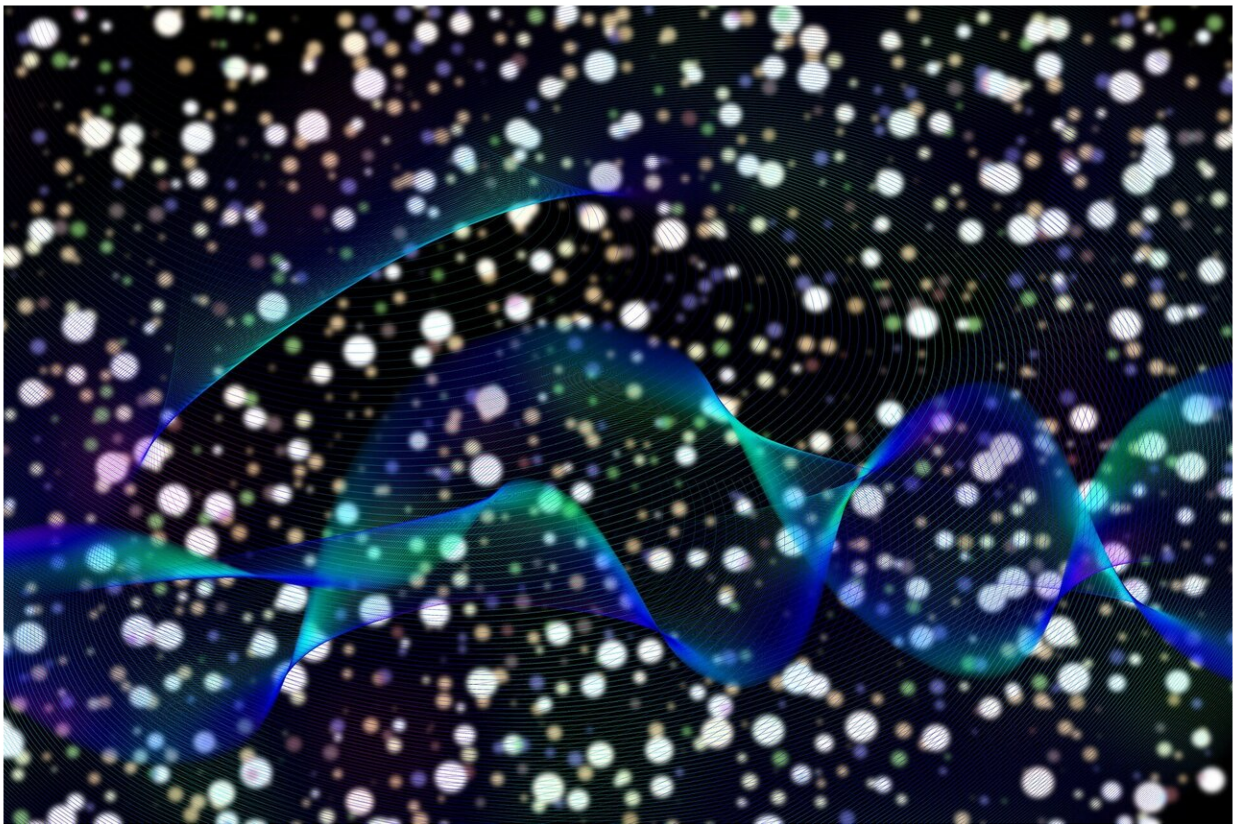

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Physicists from Germany, Denmark, and Austria have succeeded in creating a kind of turnstile for light in glass fibers that allows the light particles to only pass through one at a time

Glass fibers, which guide laser light, are the backbone of today's modern information society. If you think of laser light as a stream of light particles, so-called photons, then these are completely independent of each other and their exact arrival time is left to chance. In particular, two photons may arrive at the receiver simultaneously. For many applications, however, it is desirable that one photon is registered after the other, i.e. that the light particles are lined up like a string of pearls.

Such isolated photons are, for example, a basic requirement for quantum communication, where one can communicate in a fundamentally tap-proof way. Until now, single quantum emitters such as a single atom or a single molecule have typically acted as sources for such streams of individual photons. If the quantum emitter is excited with laser light and fluoresces, it will always emit exactly one photon with each quantum leap. For this type of source, it is then still a challenge to efficiently "feed" the emitted photons into a glass fiber in order to send as many of them as possible to the receiver.

Scientists from Germany, Denmark and Austria have now succeeded for the first time in directly converting laser light in optical fibers into a stream of isolated photons by means of a novel effect. The proposal for the experiment came from theoretical physicists Dr. Sahand Mahmoodian and Prof. Klemens Hammerer at the Leibniz University Hannover and colleagues from the University of Copenhagen. It was then carried out in the research group of Prof. Dr. Arno Rauschenbeutel at Humboldt University of Berlin. For this purpose, the researchers used a powerful atom-light interface, in which atoms are trapped near a so-called optical nanofiber and coupled in a controlled way to the light guided in the nanofiber.

These special glass fibers are one hundred times thinner than a human hair and the atoms are held in place at 0.2 micrometers from the glass fiber surface using tweezers made of laser light. At the same time, they are cooled by laser light to a temperature of a few millionths of a degree above absolute zero. This system enabled the researchers to precisely control the number of atoms along the laser beam. In the experiment, the researchers then analyzed how often the photons came out of the fiber individually or in pairs.

When about 150 atoms were trapped near the nanofiber, it turned out that the transmitted light consisted practically only of isolated photons. So, collectively, the atoms acted for the photons like a turnstile that regulates a stream of people. Surprisingly, the effect was the opposite when the number of atoms was increased: Then the atoms let the photons pass preferably in pairs.

This discovery opens up a completely new way to realize bright, fiber-integrated single-photon sources. At the same time, the working principle demonstrated by the researchers can be applied to wide ranges of the electromagnetic spectrum (microwaves to X-rays). This opens up the possibility of generating single photons in spectral ranges for which no sources are available so far. The researchers have already submitted a patent application for this technology.

More information: Adarsh S. Prasad et al. Correlating photons using the collective nonlinear response of atoms weakly coupled to an optical mode, *Nature Photonics* (2020). DOI: 10.1038/s41566-020-0692-z

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