Control on shape of light particles opens the way to 'quantum internet'

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In the same way as we now connect computers in networks through optical signals, it could also be possible to connect future quantum computers in a 'quantum internet'. The optical signals would then consist of individual light particles or photons. One prerequisite for a working quantum internet is control of the shape of these photons. Researchers at Eindhoven University of Technology (TU/e) and the FOM foundation have now succeeded for the first time in getting this control within the required short time.

These findings are published today in *Nature Communications*.

Quantum computers are the dream computers of the future. They use the unique physics of the smallest particles- those described by quantum mechanics - to perform calculations. While today's computers use bits that can be either 0 or 1, quantum computers perform calculations with 'qubits', which can be both 0 and 1 at the same time. That creates an unprecedented degree of extra computing power, which gives quantum computers much greater capabilities than today's computers.

Quantum internet

Quantum computers could in principle communicate with each other by exchanging individual photons to create a 'quantum internet'. The shape of the photons, in other words how their energy is distributed over time, is vital for successful transmission of information. This shape must be symmetric in time, while photons that are emitted by atoms normally have an asymmetric shape. Therefore, this process requires external control in order to create a quantum internet.

Optical cavity

Researchers at TU/e and FOM have succeeded in getting the required degree of control by embedding a quantum dot - a piece of semiconductor material that can transmit photons - into a 'photonic crystal', thereby creating an optical cavity. Then the researchers applied a very short electrical pulse to the cavity, which influences how the quantum dot interacts with it, and how the photon is emitted. By varying the strength of this pulse, they were able to control the shape of the transmitted photons.

Within a billionth of a second

The Eindhoven researchers are the first to achieve this, thanks to the use of electrical pulses shorter than nanosecond, a billionth of a second. This is vital for use in quantum communication, as research leader Andrea Fiore of TU/e explains: "The emission of a photon only lasts for one nanosecond, so if you want to change anything you have to do it within that time. It's like the shutter of a high-speed camera, which has to be very short if you want to capture something that changes very fast in an image. By controlling the speed at which you send a photon, you can in principle achieve very efficient exchange of photons, which is important for the future quantum internet."

More information: Francesco Pagliano et al, Dynamically controlling the emission of single excitons in photonic crystal cavities, *Nature Communications* (15 December 2014) DOI: 10.1038/ncomm6786

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