# Fast photon control brings quantum photonic technologies closer

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(PhysOrg.com) -- Using photons instead of electrons to transmit information could lead to faster and more secure ways to communicate, among other advantages. Now a team of physicists has taken another step toward realizing quantum photonic technologies by demonstrating how to quickly manipulate single photons at the same wavelengths used in existing optical telecommunications networks. The ability to control a photon's path and polarization in the time of a few nanoseconds could allow photonic circuits to be integrated with existing optical telecom networks, leading to significant improvements.

The physicists, from the University of Bristol in Bristol, UK, Heriot-Watt University in Edinburgh, UK, and the Kavli Institute of Nanoscience in Delft, The Netherlands, have published their study on the fast control of the path and polarization of single photons in a recent issue of Physical Review Letters.

The physicists worked on a quantum photonic device consisting of circuits through which single photons move, where the circuits can be reconfigured to change the path and polarization of a photon. One of the challenges for these quantum photonics circuits is to manipulate single-photon and multi-photon states at a fast rate.

To address this challenge, the researchers used lithium niobate waveguides, which have proven to be capable of fast manipulation in current telecom modulators. By taking advantage of the electro-optic effect, the researchers demonstrated that applying a voltage to electrodes near the waveguide can rapidly manipulate quantum states of light made of one or two photons. They demonstrated this fast path and polarization control of photon pairs generated at the 1550-nm wavelength, which is used in telecom networks.

“In this experiment, we demonstrate switching between two configurations of the circuit, each one leading to a different quantum state,” lead author Damien Bonneau of the University of Bristol told PhysOrg.com. “The reconfiguration rate was set at 4 MHz while previous experiments were performed with circuits reconfigured every several seconds. Switches using essentially the same technology are used every day in telecommunication networks to switch bits of information encoded in light pulses at 40 GHz. Such switches could in principle be used at a single-photon level too.”

As Bonneau explained, the lithium niobate waveguide’s ability to manipulate quantum states of light provides a distinctly different approach compared with previous methods that worked much slower.

“Until now, on-chip manipulation of quantum states of light had relied on heaters acting as slow phase shifters,” Bonneau said. “We demonstrate here that, by using one of the technologies on which the internet is built, one can not only switch light packets for routing classical information, but also rapidly engineer and manipulate quantum states of light.”

As the scientists explained, the ability to rapidly control the polarization and path of single photons on a single platform will be useful for both fundamental quantum science and quantum technologies. They plan to expand their research to work toward several of these applications in the future.

“Lithium niobate, the material which these devices are made of, can be used to probabilistically generate photons as well," Bonneau said. "Superconducting single photon detectors could also be integrated onto such a chip. A technological platform combining probabilistic sources of single photons, circuits and detectors can open the way to several applications including reliable single-photon sources (by multiplexing several sources), quantum relays (required for long distance quantum communication), or quantum key distribution (which is required for quantum cryptography)."

**More information:** Damien Bonneau, et al. "Fast Path and Polarization Manipulation of Telecom Wavelength Single Photons in Lithium Niobate Waveguide Devices." *PRL* 108, 053601 (2012). DOI: 10.1103/PhysRevLett.108.053601