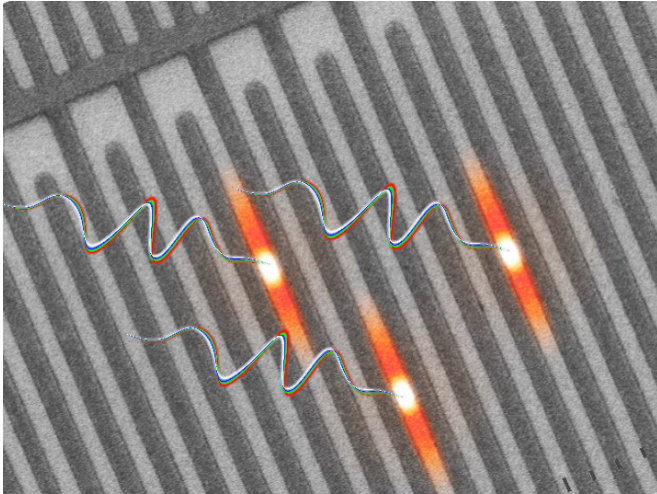


Single-photon detector can count to four

15 December 2017, by Ken Kingery



The image depicts three photons passing through a superconducting nanowire, causing the nanowire to heat up and disrupting the super-current. Credit: Duke University

Engineers have shown that a widely used method of detecting single photons can also count the presence of at least four photons at a time. The researchers say this discovery will unlock new capabilities in physics labs working in quantum information science around the world, while providing easier paths to developing quantum-based technologies.

The study was a collaboration between Duke University, the Ohio State University and industry partner Quantum Opus, and appeared online on December 14 in the journal *Optica*.

"Experts in the field were trying to do this more than a decade ago, but their back-of-the-envelope calculations concluded it would be impossible," said Daniel Gauthier, a professor of physics at Ohio State who was formerly the chair of physics at Duke. "They went on to do different things and never revisited it. They had it locked in their mind that it wasn't possible and that it wasn't worth spending time on."

"When we presented our data, world experts were just blown away," continued Jungsang Kim, professor of electrical and computer engineering at Duke. "It's neat having a group like ours that got started a bit later decide to try something because we didn't have any blinders on."

The discovery deals with a new method for using a [photon](#) detector called a superconducting nanowire single-photon detector (SNSPD).

At the heart of the detector is a superconducting filament. A superconductor is a special material that can carry an electric current forever with zero losses at low temperatures. But just like a normal piece of copper wire, a superconductor can only carry so much electricity at once.

A SNSPD works by charging a looped segment of superconducting wire with an electric current close to its maximum limit. When a photon passes by, it causes that maximum limit in a small portion of the wire to drop, creating a brief loss of superconductivity. That loss, in turn, causes an [electrical signal](#) to mark the presence of the photon.

In the new setup, the researchers pay special attention to the specific shape of the initial spike in the electrical signal, and show that they can get enough detail to correctly count at least four photons traveling together in a packet.

"Photon-number-resolution is very useful for a lot of quantum information/communication and quantum optics experiments, but it's not an easy task," said Clinton Cahall, an electrical engineering doctoral student at Duke and first author of the paper. "None of the commercial options are based on superconductors, which provide the best performance. And while other laboratories have built superconducting detectors with this ability, they're rare and lack the ease of our setup as well as its sensitivity in important areas such as counting speed or timing resolution."

For other labs to make use of the discovery, all they

would need is a specific type of amplifier for boosting the SNSPD's tiny electrical signal. The amplifier must work at the same [low temperatures](#) as the SNSPD—minus 452 degrees Fahrenheit—to reduce background noise. It also must have wide bandwidth to avoid distorting the signal. Such amplifiers are already commercially available and many labs have them.

The results will allow researchers around the world working in quantum mechanics to immediately gain new abilities with their existing equipment. As one example, the Duke-Ohio State group also recently reported how using the timing of incoming photons in addition to their quantum states could greatly increase the speed of [quantum](#) encryption techniques.

The team is now working to optimize their setup to see just how far they can stretch its abilities. They believe with the right electronics and a bit of practice, they could count 10 or even 20 photons at a time. The group has also filed for a patent to create off-the-shelf devices based on their method.

More information: Clinton Cahall et al, Multi-photon detection using a conventional superconducting nanowire single-photon detector, *Optica* (2017). [DOI: 10.1364/OPTICA.4.001534](https://doi.org/10.1364/OPTICA.4.001534)

Provided by Duke University

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