Scientists demonstrate quantum radar prototype

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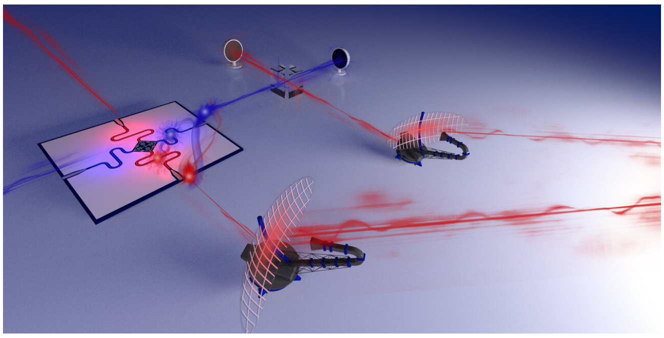

Illustration of a quantum radar prototype. Credit: © IST Austria/Philip Krantz

Physicists at the Institute of Science and Technology Austria (IST Austria) have invented a new radar prototype that uses quantum entanglement as a method of object detection. This successful integration of quantum mechanics into devices could significantly impact the biomedical and security industries. The research is published in the journal *Science Advances*.

Quantum entanglement is a physical phenomenon whereby two particles remain interconnected, sharing physical traits regardless of how far apart they are from one another. Now, scientists from the research group of Professor Johannes Fink at the Institute of Science and Technology Austria (IST Austria) along with collaborators Stefano Pirandola from the Massachusetts Institute of Technology (MIT) and the University of York, UK, and David Vitali from the University of Camerino, Italy—have demonstrated a new type of detection technology called microwave quantum illumination that utilizes entangled microwave photons as a method of detection. The prototype, which is also known as a quantum radar, is able to detect objects in noisy thermal environments where classical radar systems often fail. The technology has potential applications for ultra-low power biomedical imaging and security scanners.

Using quantum entanglement as a new form of detection

The working principles behind the device are simple: Instead of using conventional microwaves, the researchers entangle two groups of photons, which are called the signal and idler photons. The signal photons are sent out towards the object of interest, whilst the idler photons are measured in relative isolation, free from interference and noise. When the signal photons are reflected back, true entanglement between the signal and idler photons is lost, but a small amount of correlation survives, creating a signature or pattern that describes the existence or the absence of the target object—irrespective of the noise within the environment.

"What we have demonstrated is a proof of concept for the microwave quantum radar," says lead author Shabir Barzanjeh, whose previous research helped advance the theoretical notion behind quantum enhanced radar technology. "Using entanglement generated at a few thousandths of a degree above absolute zero (-273.14 °C), we have been able to detect low reflectivity objects at room-temperature."

Quantum technology can outperform classical low-power radar

While quantum entanglement in itself is fragile in nature, the device has a few advantages over conventional classical radars. For instance, at low power levels, conventional radar systems typically suffer from poor sensitivity as they have trouble distinguishing the radiation reflected by the object from naturally occurring background radiation noise. Quantum illumination offers a solution to this problem as the similarities between the signal and idler photons—generated by quantum entanglement—makes it more effective to distinguish the signal photons (received from the object of interest) from the noise generated within the environment.

Barzanjeh, who is now an assistant professor at the University of Calgary, says, "The main message behind our research is that quantum radar or quantum microwave illumination is not only possible in theory, but also in practice. When benchmarked against classical low-power detectors in the same conditions, we see that at very low-signal photon numbers, quantum-enhanced detection can be superior."

Throughout history, basic science has been one of the key drivers of innovation, paradigm shift and technological breakthrough. While still a proof of concept, the group's research has effectively demonstrated a new method of detection that, in some cases, may be superior to classical radar.

"Throughout history, proofs of concept, such as the one we have demonstrated here, have often served as prominent milestones toward future technological advancements. It will be interesting to see the future implications of this research, particularly for short-range microwave sensors," says Barzanjeh.

Last author and group leader Professor Johannes Fink says, "This scientific result was only possible by bringing together theoretical and experimental physicists that are driven by the curiosity of how quantum mechanics can help to push the fundamental limits of sensing. But to show an advantage in practical situations, we will also need the help of experienced electrical engineers, and there still remains a lot of work to be done in order to make our result applicable to real-world detection tasks."

More information: "Microwave quantum illumination using a digital receiver" *Science Advances* (2020). DOI: 10.1126/sciadv.abb0451

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