Reducing noise in quantum operation at room temperature

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(PhysOrg.com) -- "A quantum memory is a crucial component of future quantum information processing technologies. Among these technologies, a quantum communications system based on light will enable vastly improved performance over conventional systems, and allow quantum computers to be connected," Ian Walmsley tells *PhysOrg.com*. Walmsley is a scientist at the University of Oxford in the United Kingdom. "Building such as system will require a means to effect the temporary storage of single light quanta – photons."

One of the obstacles involved in building a quantum memory is that it is difficult to get a true quantum effect due to the decoherence associated with noise, when working at room temperature. "With previous demonstrations in this quantum regime, ultracold atomic gases or cryogenic solid state materials have been used as a storage medium," Walmsley explains.

Walmsley is part of a group working to create room temperature solutions for quantum computing. The group, working out of Clarendon Laboratory at Oxford, includes Klaus Reim, Patrick Michelberger, Ka Chung Lee, Joshua Nunn and Nathan Langford as well as Walmsley. The results of their efforts can be seen in *Physical Review Letters*: "Single-Photon-Level Quantum Memory at Room Temperature."

"Our breakthrough is two-fold," Walmsley explains. "Using a so-called Raman interaction allowed a dramatic increase in potential bandwidth. The second advantage is that you can use these warm vapors, allowing quantum operation at room temperature."

In order to make their quantum memory work, Walmsley and his colleagues store information in the collective state of atoms in a warm vapor. "This concept has been around for years, but we are looking at how to make it work practically at room temperature."

The team at Oxford uses a strong off-resonant control pulse to store a weak quantum light pulse. "It's two step," he says. "We put in the quantum light with a control pulse. Because their frequencies are tuned out of resonance with the atoms, neither is absorbed without the other. This allows you larger bandwidth."

"Additionally, because neither is absorbed without the other, you don't have extraneous atoms that have absorbed energy from the control pulse alone, and which can then give away this energy in the form of noise photons," Walmsley continues. "It's these extra photons that have added to the noise in previous attempts, and been a deal-breaker for room-temperature quantum memories." The use of warm atomic cesium vapors show that quantum operation can be achieved in ambient conditions.

Walmsley says that, already, their technique offers applications. "Even though the memory isn't perfect yet, there are some things we can do, like entanglement distillation." He explains that he thinks that this technique could improve the efficiency of quantum repeaters. "The idea of a quantum repeater has been around for about 12 years now, but without a memory you get a degree of degraded quality so that signals are lost. Theoretically, our system could make quantum repeaters a reality."

Room temperature quantum memory would be a great step forward for quantum communications and quantum information processing.

Quantum repeaters might need to be placed in remote areas, or in areas that are warm. Reliable quantum memory will be needed in the coming years as secure quantum communications are in greater demand. Walmsley hopes that his group can be at the forefront of turning the possibilities into realities.

"While there are things we can do now, there is still a great deal of room for improvement," he says. "We want to improve efficiency, and the stability of the memory." Another important point will be to shrink the technology. "We want to miniaturize it so that it is small enough to integrate into fiber optic networks," Walmsley continues. "This is a definite breakthrough, but we still have some way to go."

More information: K.F. Reim, P. Michelberger, K.C. Lee, J. Nunn, N.K. Langford, and I.A. Walmsley, "Single-Photon-Level Quantum Memory at Room Temperature," *Physical Review Letters* (2011). Available online: link.aps.org/doi/10.1103/PhysRevLett.107.053603

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