Fock states could hold clues to quantum memory components

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(PhysOrg.com) -- "Fock states will play a role in the future of quantum computing," Andrew Cleland tells *PhysOrg.com*. "We have completed the first experimental measurement of the time decay of Fock states in a superconducting quantum circuit, and we believe this will provide useful information as we work toward developing a quantum computer." Cleland is a professor at the University of California, Santa Barbara, and works with a group headed by John Martinis.

The UC Santa Barbara group used a microwave coplanar waveguide resonator with a superconducting qubit in order to provide the control needed to create, and to measure the decay of, the Fock states. "Learning more about the fundamentals of these states can provide us with some very practical information." The group's results are reported in *Physical Review Letters*: "Measurement of the Decay of Fock States in a Superconducting Quantum Circuit." Haohua Wang, a postdoctoral scientist in the Martinis group, was the lead researcher on the experiment.

"What we found," Cleland continues, "is that the time decay of these Fock states follows precisely what is expected in theory. It gives us some good information about how these states work, as well as a foundation on which we can build elements for a quantum computer."

Cleland also points out that the work done by the Martinis group produced more than one photon for the experiment, and that hadn't been done before. "Typically experiments use a combination of a zero photon

Fock state and a one photon state. No one until now has developed the technology to show that you could controllably create states with more than one photon. We did." The Martinis group results indicate that it is possible to control Fock states with up to 15 photons.

Because Fock states are the fundamental quantum states of a harmonic oscillator, they are important to study. "These oscillators occur in many natural systems," Cleland explains. "The electronic versions we studied are known as electromagnetic resonators. These resonators have a number of uses for quantum communications and computing."

One of the uses that such resonators might have includes memory elements for quantum computing. "Of course," Cleland qualifies, "no one is close to doing the kinds of computations we'd like to be able to do, but this is a step that could get us there down the road." The memory elements he refers to need a certain level of control that the Martinis group was able to develop with their present experimental setup.

"The applications associated with having more than one photon – one of the things we showed in our experiment – are not as clear as a one photon memory function," Cleland admits. But he does believe that there could be uses for such states in quantum simulation. "Right now, simulating the interactions between molecules requires giant computers to work a long time. It's not very efficient. Quantum simulation could help us more efficiently see accurate interactions with a relatively simple quantum simulator."

Cleland concedes that the Santa Barbara group is more interested in building a quantum computer, even though he can see other possible uses for the work they have done. "We've created a level of control that might make it possible to program quantum memory, and that is exciting itself."

<u>More Information</u>:
H. Wang, M. Hofheinz, M. Ansmann, R. C. Bialczak, E. Lucero, M. Neeley, A. D. O'Connell, D. Sank, J. Wenner, A. N. Cleland, and John M. Martinis. "Measurement of the Decay of Fock States in a Superconducting Quantum Circuit." *Physical Review Letters* (2008). Available online: link.aps.org/doi/10.1103/PhysRevLett.101.240401