Making quantum computing scalable

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(PhysOrg.com) -- Quantum information processing is one of the hottest areas of science and technology right now. Making quantum information processing scalable is an important part of the efforts involved with regard to practical quantum computing. "By tuning the gap of a superconducting qubit, we can allow different types of coupling for use in quantum information processing," Hans Mooij tells *PhysOrg.com*.

Mooij is part of a group at the Kavli Institute of Nanoscience at Delft University of Technology in The Netherlands. Along with Paauw, Fedorov and Harmans, Mooij has successfully demonstrated that such tenability is possible. The work is published in *Physical Review Letters*: "Tuning the Gap of a Superconducting Flux Qubit."

"A qubit exists in two states at the same time," Mooij explains, "and the strength of the coupling between them is the gap." This gap represents energy splitting, and the type of qubit used by the group in Delft is known as a superconducting flux qubit. This type of qubit is needed in large quantities in order to make quantum information processing scalable. But these qubits also have to be able to couple - and decouple - in an efficient manner.

Mooij says that it is possible to strongly couple the qubits to a resonator. "We choose to make the qubits the same frequency of the resonator. We tune this gap of the superconducting qubit to a harmonic oscillator. The qubit communicates with the oscillator while they are at the same frequency." After a set amount of time, it is possible to then decouple the qubit from the oscillator and tune a new qubit to the frequency. Tuning is done by means of the addition of another flux loop in order to control the energy splitting. The Netherlands group found that it is possible to do this within nanoseconds - making the process very fast.

The next step, Mooij explains, is to transfer information from the resonator to another qubit. So far, the group has only shown that gap tuning is possible with one qubit, and no transfer of information has taken place. However, it should be possible for a qubit to communicate with the resonator, and then for the resonator to communicate that information to another qubit. "Any pair of qubits can be chosen for the interaction," he points out. "If we can do it with one, as we have demonstrated, we can do it with many. But we still have not gotten any information from the resonator, and we need to take the next step."

Tunable qubits are applicable in a number of circumstances. Being able to control the qubits' frequencies has practical applications in terms of quantum optics and physics, as well as for quantum gates. Being able to control qubits and their coupling is a potentially large step forward in terms of technological and scientific development.

Fundamentally, Mooij says, the study of qubit tuning by resonance holds other interest. "We were happy to see that after you change the parameters, the qubit remains intact. We could not be sure of that. Study of this process, as well as its use in other experiments, could help us better understand different aspects of fundamental physics."

More information: F. G. Paauw, A. Fedorov, C. J.P. M Harmans, and J. E. Mooij, "Tuning the Gap of a Superconducting Flux Qubit." *Physical Review Letters* (2009). Available online: link.aps.org/doi/10.1103/PhysRevLett.102.090501.