Taking Superconducting Qubits to the Next Generation

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A quantum computer could solve certain important tasks that are intractable to solve using even the fastest conventional supercomputers. However, the construction of a quantum computer remains a major technical challenge because of opposing requirements: On the one hand, we must interact with the quantum system in order perform computations and extract the results. On the other hand, the quantum system must retain its quantum properties throughout the calculation. Quantum computers are therefore inherently subject to "decoherence" which causes errors in the computation and must be corrected.

Fault tolerant quantum computing is possible by employing quantum error correction techniques. In this talk we show the first implementation of a true quantum code using 4 lithographically defined superconducting qubits in a square lattice capable of measuring both types of possible quantum errors occurring on a single qubit. The experiment requires highly coherent qubits, high quality quantum operations implementing the detecting circuit, and a high quality independent qubit measurement set-up.

Looking beyond this implementation, there remains both theoretical and experimental control hurdles which must be overcome to build verifiably reliable quantum networks of qubits. We will present some experiments which point towards these important questions and give proposals for future integration capability, measurement integration, and scalable control architectures. We focus on a variety of questions which will increasingly become important as we move towards a larger network of qubits.