C O L L O Q U I U M

Special Colloquium

Measurement and Control of Superconducting Qubits Using Single Flux Quantum Digital Logic

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One of the remarkable recent discoveries in information science is that quantum mechanics can lead to efficient solutions for problems that are intractable on conventional classical computers. While there has been tremendous recent progress in the realization of small-scale quantum circuits comprising of order 10 quantum bits (“qubits”), research indicates that a fault-tolerant quantum computer that exceeds what is possible on existing classical machines will require a network of thousands or millions of qubits, far beyond current capabilities. Robust approaches to the measurement and control of large-scale next-generation quantum machines have yet to be developed.

In this talk I describe an experimental program to develop high-fidelity qubit measurement and control circuitry based on the superconducting Single Flux Quantum (SFQ) digital logic family. Qubit measurement is performed by mapping the state to the microwave photon occupation of a linear resonator followed by subsequent microwave photodetection. This scheme provides access to the binary digital output of qubit measurement at the millikelvin experimental stage, without the need for room-temperature heterodyne measurement and thresholding. Coherent control of the qubit is performed using complex trains of quantized SFQ voltage pulses derived from optimal control theory. Each of these pulses provides a delta function-like kick to the qubit, inducing a complex trajectory on the Bloch sphere that is tailored to minimize leakage errors. These two efforts point a direction toward the integration of a large-scale superconducting quantum processor with proximal classical superconducting logic for the purposes of reducing latency, wiring heat load, and overall system footprint.