Coherent dynamics of a Josephson Charge Qubit

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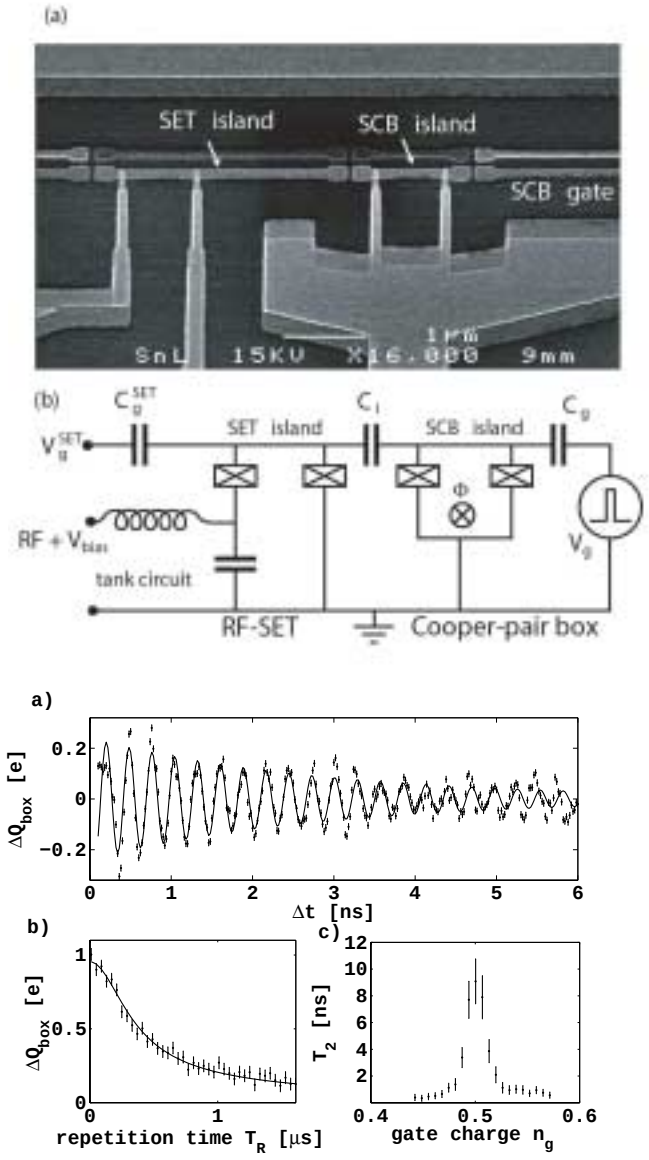
In order to experimentally realize a superconducting charge qubit, one must overcome several challenging problems. The first, which is surprisingly subtle and difficult, involves producing Cooper-pair-boxes with robust even-parity states. One must then optimize the readout while simultaneously minimizing its back-action on the qubit. Finally, the mechanisms of decoherence in Josephson junction qubits must be understood if we are to scale up to many qubits. We must identify both the sources of dephasing and relaxation, and how they couple to the qubit. Although there is much to learn from the mature field of spin physics, superconducting qubits are fundamentally different in that they are mesoscopic objects, the noise is very asymmetric, and measurements are not made on ensembles.

We present experimental studies of a Josephson charge qubit (Cooper-pair-box) that uses radio-frequency, single-electron-transistor (RF-SET) readout. We describe the evolution of our sample fabrication process that led to robust even-parity boxes with SET's that can be operated in the sub-gap regime in a manner that minimizes the backaction. Fast DC pulses are used to manipulate the qubit and coherent oscillations with a high fidelity are consistently observed. The reduction from 100% is understood as an adiabatic effect of the finite pulse rise-time. Measurements of dephasing for the full range of gate charge and on time scales extending to the sub-nanosecond regime have been made. These allow us to attribute the main source of dephasing to fluctuations that couple predominantly to charge.

Measured relaxation times vary considerably and can be smaller than what is expected from either the Ohmic control circuitry or extrapolation of the known 1/f spectrum to GHz frequencies. Investigations of various relaxation processes as well as backaction due to the SET are also presented.



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