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Flux Qubits: Coupling and Decoherence[1]

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The principles of the three-junction flux qubit are briefly reviewed. We investigated two such qubits coupled together via their mutual inductance and via the dc SQUID (Superconducting Quantum Interference Device) that reads out their magnetic flux states. On-chip flux lines enabled us to bias the two qubits individually. Microwave spectroscopy revealed that the energy splittings of the symmetric and antisymmetric states of the two qubits at their respective degeneracy points were remarkably close, 8.872 GHz and 8.990 GHz. At the double degeneracy point, the energy difference between the first and second excited states of the coupled qubits was enhanced by level repulsion as predicted. We performed time domain measurements on the individual qubits and on excited states of the coupled qubits, including Rabi oscillations, flux echoes, Ramsey fringes and measurements of the relaxation time, and also determined the linewidths of the individual peaks. These measurements enable us to compare the relaxation and decoherence times of the individual and coupled qubits. For example, at the double degeneracy point of the coupled qubits, the decoherence rate determined by flux echoes is equal to the sum of the rates in the separate qubits. Sources of decoherence are discussed, and estimates given of the various known contributions including those of the biasing and measurement circuitry. This work was performed in collaboration with T. Hime, B.L.T. Plourde, P.A. Reichardt, T.L. Robertson, A.V. Ustinov and C.-E. Wu.

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