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Abstract

Studies of Quantum Transitions of Magnetic Flux in a rf SQUID Qubit

By

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At low temperature and low damping, the magnetic flux of a rf Superconducting QUantum Interference Device (SQUID) acts as a macroscopic quantum variable whose dynamic is described by a double well potential. A rf SQUID consists of a superconducting loop interrupted by a thin insulating barrier, known as a Josephson junction. The modified rf SQUID design discussed in this thesis has independent, in situ, controls that allow controlling the barrier height between the potential wells and their relative tilt. This high level of control of the potential together with the capability to implement an experimental setup optimized to reduce coupling to external sources of noise, made this system ideal not only for tests of quantum transition at a macroscopic level, but also as a scalable solid state device for quantum computation.

A variety of measurements of quantum phenomena are reported in this thesis, including microwave level spectroscopy, coherent oscillations, and macroscopic resonant tunneling (MRT). These measurements are compared with theoretical models to study the possible sources of decoherence in a rf SQUID qubit. The analysis confirmed that the main source of decoherence is not due to coupling to the external environment, but it can be linked to intrinsic low frequency flux noise. Work from many groups over the last several years has shown that the performance of a superconductive qubit is limited by coupling to spurious defects in the materials used for the device fabrication. In this work we analyze the possibility of using the MRT as a tool for future studies of effects of materials and fabrication process in the realization of improved qubits, and we also explore the feasibility for measurements of quantum phenomena that involve fast pulsing of the potential barrier height.

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