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Abstract

Studies of Decoherence in rf SQUID Qubits

By

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Usually quantum mechanical behavior is associated with single elementary particles or a moderate size group of these particles such as atoms or molecules. However a distinctly macroscopic object such as rf SQUID is capable of uniquely quantum mechanical behavior if it is sufficiently decoupled from its environment. A rf SQUID consists of a superconducting loop interrupted by thin insulating barrier, known as a Josephson junction. When the loop is externally biased with half a flux quantum, the potential energy forms a double well potential as function of the total flux, with the two wells representing circulating currents in opposite directions consisting of 10^9 Cooper pairs. At low temperatures and for suitable junction parameters this system behaves quantum mechanically with a Hamiltonian analogous to a particle in this potential. The eigenstates of the system are ideal for tests of quantum mechanics on a macroscopic level and can be used as basis states for quantum computation.

These devices are realized using Nb/AlOx/Nb junctions that are patterned using electron beam lithography. The experimental setup was carefully designed to reduce coupling of external noise sources to the rf SQUID. The setup was extensively tested to confirm that the external environment is not the dominant source of decoherence. Careful measurement of the system parameters allowed for the accurate calculations necessary to compare the measurements with theory. Coherent oscillations were observed between the ground and excited states within the same fluxoid state of the rf SQUID using pulsed microwaves to couple the states. The decay of these oscillations along with microwave spectroscopy and direct measurement of the lifetime of the excited state were used to characterize the source or sources of decoherence. There exists low frequency flux noise and a short lifetime for the excited state that are not consistent with known noise sources.

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