Temperature dependent spin-diffusion as a mechanism of flux noise and decoherence in SQUIDs and qubits

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Abstract

The intrinsic flux noise observed in superconducting quantum interference devices (SQUIDs) is the main source of decoherence for superconducting qubits. Its microscopic origin is thought to be the fluctuation of electron spin impurities, but the frequency and temperature dependence observed in experiments does not agree with the usual $1/f$ models. We present a theory of flux noise due to spin-diffusion that shows how these observations can be explained by the assumption of a spin-diffusion constant that increases with increasing temperature. Our theory predicts a crossing frequency band, separating regions for increasing and decreasing noise spectral weight as the temperature increases. We show measurements of flux noise in the $10 - 120$ mK temperature range in SQUID qubits that confirm this prediction, allowing the extraction of the spin-diffusion constant and its temperature dependence.