MAR09-2008-005351

Abstract for an Invited Paper
for the MAR09 Meeting of
the American Physical Society

Noise and Dephasing from Surface Magnetic States in Superconducting Circuits

ROBERT MCDERMOTT, University of Wisconsin

Superconducting qubits are a leading candidate for scalable quantum information processing. In order to realize the full potential of these qubits, it is necessary to develop a more complete understanding of the microscopic physics that governs dissipation and dephasing of the quantum state. In the case of the Josephson phase and flux qubits, the dominant dephasing mechanism is an apparent low-frequency magnetic flux noise with a $1/f$ spectrum and a magnitude of several $\mu\Phi_0/\mathrm{Hz}^{1/2}$ at 1 Hz, where $\Phi_0 = h/2e$ is the magnetic flux quantum. Recent qubit results are compatible with the excess low-frequency noise measured by researchers at Berkeley more that 20 years ago in a series of experiments on SQUIDs cooled to millikelvin temperatures. The origin of this excess noise was never understood. Here we describe studies of flux noise and temperature-dependent magnetization in SQUIDs cooled to millikelvin temperatures. We observe that the flux threading the SQUIDs increases as $1/T$ as temperature is lowered; moreover, the flux change is proportional to the density of trapped vortices. The data is compatible with the thermal polarization of unpaired surface spins in the trapped fields of the vortices. In the absence of trapped flux, we observe evidence of spin- glass freezing at low temperature. These results suggest a microscopic explanation for the universal $1/f$ flux noise in SQUIDs and superconducting qubits, and suggest that suitable surface treatments of the superconducting films will lower the density of magnetic states, leading to superconducting devices with lower noise and solid-state qubits with improved coherence times.