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Spectroscopy of Nanoscale Two-Level Systems in Insulating Films
BAHMAN SARABI, ARUNA RAMANAYAKA, Laboratory for Physical Sciences, FREDERICK WELLSTOOD, University of Maryland,College Park, KEVIN OSBORN, Laboratory for Physical Sciences — Nanoscale tunneling two level systems (TLSs) are viewed as defects in dielectric films because they are parasitic to the performance of superconducting qubits and resonators. Using a calibrated and uniform dc electric field within a special superconducting resonator we modify the energy potential of random TLSs in amorphous insulating films and measure them. As the dc electric field is applied, TLS energies are observed near the tunneling energies from their double-well degeneracy. From these measurements, the dipole moment projected along the field axis is directly extracted for each TLS. The random distribution of projected dipole moments shows that there are multiple dipole sizes in a silicon nitride film. This contrasts other techniques which find a single dipole size in an amorphous film. Spectroscopic splittings are observed which arise from a coherent exchange of a single photon between a TLS and the resonator, and they allow an overconstrained validation of cavity quantum electrodynamics with a TLS. The method used to measure multiple dipole moments is believed to be generally useful for the classification of TLSs, which can be used to test and screen films fabricated for coherent superconducting devices.

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