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Study of Microscopic Two-Level Fluctuators in Superconducting Coplanar Waveguide Circuit

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Microscopic two level fluctuators (TLFs) remain the most mysterious obstacle in developing scalable superconducting quantum bits (qubits). External noise sources interacting with the qubit through the electronic circuits, electrical wirings, and external electromagnetic field fluctuation can be largely suppressed by adding additional filters and shields. However, decoherence introduced by the intrinsic noise sources that originated within the qubit devices are the most difficult to be identified and thus eliminated. In this work, we report a study of the origin of TLFs by fabricating NbN/AlN/NbN SQUID qubits embedded in a superconducting epitaxial grown NbN coplanar waveguide circuit on single-crystal MgO substrate. The qubit acting as an artificial atom interacts with the microwave photon in one dimensional waveguide circuit. When the microwave photon energy is equal to the energy spacing between the two microscopic states of the TLFs, the qubit spectrum will be disrupted by local spectral splittings due to the TLFs and qubit interactions, as shown in Fig. 1. A total of 6 SQUID qubits are capacitively coupled with the center conductor of a Z=50 Ohm superconducting transmission line. Such an integrated circuit scheme is simple enough for studying the TLSs originated inside the materials of the SQUIDs and substrate. The critical current density of the tunnel junctions in the SQUIDs is Jc=100 A/cm^2 which inferred from the test JJs on the same wafer. Detailed experimental procedure and results will be presented and discussed.

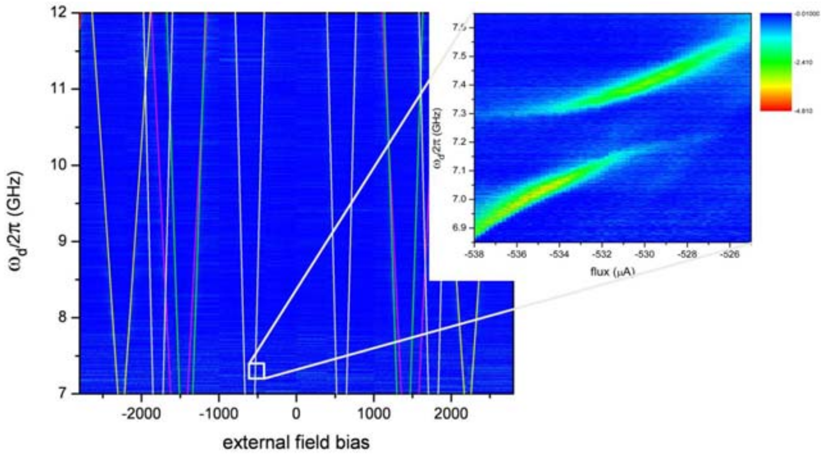

Fig 1: A demonstration of qubits spectroscopy of SQUID qubits integrated with a superconducting NbN epitaxial coplanar waveguide. The spectral splittling caused by TLS can be seen in the zoomed-in image at the right.