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## One-by-one manipulation of microscopic dipoles in amorphous oxide

Experimentally measured spectra of Josephson plasma oscillations in tunnel junctions display signatures of coherent coupling to individual microscopic defects acting as two-level systems (TLSs). These defects manifest themselves by avoided level crossings in microwave spectroscopy data reflecting the dependence of the Josephson plasma frequency on the current flowing through the junction. They are currently understood as nanoscale dipole states emerging from metastable lattice configurations in amorphous dielectrics forming the tunnel barrier of the Josephson junction. Such dipolar TLSs couple to the electrical field inside the junction which oscillates at the Josephson plasma frequency. I will present our recent experiments in which we use a Josephson junction for manipulating the quantum state of a single TLS. These experiments allow to directly measure of the energy relaxation T1 and dephasing T2 times of an individual microscopic dipole-like TLS. Driving Rabi oscillations of the junction tuned close to a resonance with TLS leads to the observation of true 4-level dynamics [1]. The multi-photon spectroscopy allows for direct probing of hybridized states in the combined junction-defect coupled quantum system [2]. New method of direct microwave driving made it possible to study the temperature dependence of coherence times of individual TLSs [3]. Moreover, the observation of TLSs which have much longer coherence times than the macroscopic Josephson qubit renders them interesting for quantum information processing purposes, which we experimentally explored by generating entanglement between two TLSs mediated by the qubit [4].

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