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Macroscopic Quantum States of Sound in a Bulk Electromechanical System

Mechanical resonators are emerging as an important new platform for quantum science and technologies.

In particular, interfacing a bulk acoustic resonator with a superconducting qubit enables the creation and control of quantum states of mechanical motion that can be assigned macroscopic masses, useful for tests of fundamental quantum mechanics as well as in quantum sensing experiments.

This work utilizes the resonant Jaynes-Cummings interaction between a high overtone resonator mode of a bulk acoustic wave resonator and a superconducting qubit, to demonstrate the preparation of Schrödinger cat states of motion. In such a state, the constituent atoms oscillate in a superposition of two opposite phases with an effective oscillating mass of 16μg. Making use of the circuit quantum acoustodynamics toolbox we have developed, we furthermore show the characterization of such states in phase space by operating our devices in the strong dispersive regime of quantum acoustodynamics.

In addition, due to the high intrinsic sensitivity of bulk acoustic modes to metric perturbations of space-time, our devices are prime candidates for compact sensors of high-frequency gravitational waves.

Besides the ability to perform protocols for quantum-enhanced sensing, we show how gravitational wave amplitudes can be bound by precise temperature measurements of the phonon modes in our devices.