Quantum control and thermometry of surface acoustic wave phonons

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I report on a recent experiment using a superconducting qubit to probe the 4 GHz fundamental mode of a surface acoustic wave (SAW) resonator. This experiment builds on prior work coupling superconducting qubits to mechanical devices, here achieving full quantum control over the SAW mode and exceeding the control achieved over earlier bulk acoustic resonator-qubit experiments. The SAW device, fabricated on a lithium niobate substrate, was designed to have a single SAW mode centered at 4 GHz, with higher order modes outside the stop band of the SAW resonator mirrors. A superconducting qubit, coupled to the SAW resonator through an electrically controlled coupler element, was fabricated on a separate sapphire substrate, with the SAW device flip-chip bonded to the qubit chip. We used the qubit to characterize the SAW resonator admittance; measure the mode occupation with no excitation, in other words a quantum thermometry measurement; and generate one- and two-phonon Fock states, as well as measure the Wigner tomograms of the resonator in its ground state; with one phonon; and with a superposition state of zero and one phonons.