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Quantum Acoustics with Superconducting Qubits YIWEN CHU, PRASHANTA KHAREL, WILLIAM RENNINGER, LUKE BURKHART, LUIGI FRUNZIO, MICHEL DEVORET, PETER RAKICH, ROBERT SCHOELKOPF, Yale University Applied Physics — In the field of quantum electro-mechanics, creating and controlling quantum states of mechanical motion is an important goal. Achieving this goal requires the interaction of a robust quantum system with a long-lived mechanical mode. We experimentally demonstrate resonant strong coupling of a superconducting qubit with the modes of a bulk acoustic phononic resonator. The system directly incorporates a piezoelectric transducer into a standard 3D transmon geometry and can be made with straightforward fabrication techniques. Both the qubit and phonon exhibit long lifetimes of many microseconds. We use this system to perform basic quantum operations on the phonons and explore the rich mode structure of the bulk acoustic resonator. Straightforward improvements to the current system would allow for more sophisticated protocols analogous to what has been demonstrated in optical and microwave resonators, resulting in a novel resource that can be used for quantum information processing in circuit QED systems.

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