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Prospects for coupling Surface Acoustic Waves to superconducting qubits

MARTIN GUSTAFSSON, Chalmers University of Technology

Recent years have seen great development in the quantum control of mechanical resonators. These usually consist of membranes, cantilevers or suspended beams, whose vibrational modes can be cooled to the quantum ground state. This presentation will focus on a different kind of micromechanical system, where the motion is not confined to a mode with fixed boundaries, but propagates along the surface of a microchip. These modes are known as Surface Acoustic Waves (SAWs), and superficially resemble ripples on water, moving with low loss along the surfaces of solids. On a piezoelectric substrate, electrode gratings known as Interdigital Transducers (IDTs) can be used to convert power between the electric and acoustic domains. Devices based on this effect are of profound technological importance as filters and analog signal processors in the RF domain. In the realm of quantum information processing, SAWs have primarily been used to transport carriers and excitons through piezoelectric semiconductors, in the electric potential wells propagating along with the mechanical wave. Our approach, however, is different in that we aim to explore the mechanical wave itself as a carrier of quantum information. We have previously shown that a single-electron transistor can be used as a local probe for SAWs, with encouraging sensitivity levels. Building on this, we now investigate the prospects for coupling a SAW beam directly to a superconducting qubit. By merging a circuit model for an IDT with a quasi-classical description of a transmon qubit, we estimate that the qubit can couple to an acoustic transmission line with approximately the same strength as to an electrical one. This type of coupling opens for acoustic analogs of recent experiments in microwave quantum optics, including the generation of non-classical acoustic states.