Approaching optimal microwave-acoustic transduction on lithium niobate using SQUID arrays

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Acoustic waves play an essential role in various classical and quantum systems, such as microwave-to-optics transducers, quantum acoustic devices, and devices that use strain to couple to spin defects. Central to these experiments is the transducer, which enables the exchange of signals between electrical and acoustic networks. This transduction is commonly achieved by exploiting piezoelectricity. However, conventional piezoelectric transducers are limited to either small efficiencies or narrow bandwidths and typically operate at fixed frequencies. These limitations restrict their utility in many applications.

We propose and demonstrate an effective method for achieving piezoelectric microwave-acoustic transduction that approaches the maximum efficiency-bandwidth permitted by the piezoelectric coupling constant of lithium niobate [1]. We use SQUID arrays to impedance-match the large complex impedance of wide-band interdigital transducers that excite Lamb waves in suspended lithium niobate. We demonstrate unprecedented efficiency x bandwidth of 440 MHz, with a maximum efficiency of 62% at 5.7 GHz. Moreover, leveraging the flux dependence of SQUIDs, we realize transducers with in-situ tunability across the 4-7 GHz band.

Our transducer is compatible with the quantum toolbox of superconducting circuits and it can be connected directly to parametric amplifiers, microwave photon counters, etc. We envision applications in microwave-to-optics conversion schemes, acoustic spectroscopy in the 4-8 GHz band, or quantum-limited phonon detection.

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