Surface Acoustic Wave phonons, mediator of quantum interactions

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Résumé

Phonons are of particular interest because mechanical deformations can mediate coherent interactions with a wide range of different quantum systems, including solid-state defects, superconducting qubits, and optical photons. Phonons thus hold promise for quantum-focused applications as diverse as sensing, information processing, and communication. In this talk, we will describe our journey in hybrid experiments involving superconducting qubits and surface acoustic waves (SAW) phonons.
We will present our initial experiment where we demonstrated the quantum control of a single confined SAW mode by a superconducting qubit(1). Such control over the phonon-photon interaction paved the way towards a phononic quantum state transfer via a multi-mode Fabry-Pérot SAW resonator(2).

From that point, we freed ourselves from SAW resonators and truly explore quantum optics like experiments with itinerant SAW phonons(3). Recently, such itinerant SAW phonon where used in a Hong-Ou-Mandel type experiment(4).

(1) K. J. Satzinger et al., "Quantum control of surface acoustic wave phonons", Nature 563, 661–665 (2018)

(2) A. Bienfait et al., "Phonon-mediated quantum state transfer and remote qubit entanglement", Science 364, 368-371 (2019)

(3) É., Dumur et al., "Quantum communication with itinerant surface acoustic wave phonons", npj Quantum Inf 7, 173 (2021)
(4) H. QIAO et al, "Splitting phonons: Building a platform for linear mechanical quantum computing", Science, 8 Jun 2023, Vol 380, Issue 6649, pp. 1030-1033 (2023)

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