Quantum and topological phononics with ultrasound waves on a chip

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Phonons hosted by mesoscopic mechanical resonators can be strongly isolated from the environment, enabling coherence times in excess of 100 ms using modern dissipation engineering techniques [1]. Tailored coupling to other quantum systems then allows manipulating the phonons' quantum state. We have, for example, used a super-conducing microwave circuit for coherent control [2], and an optical interferometer for measurement-based quantum control of phonon modes [3]. Experiments are underway to couple such long-lived phonons to non-linear quantum systems including electron spins [4] and superconducting qubits. These platforms may find applications as quantum transducers and memories [5]. In another line of research, we have realized a phononic topological insulator of the valley-Hall kind, in analogy to its photonic counterpart [6]. At its boundary, phonon modes propagate robustly and with ultralow absorption loss (~3 dB/km), thanks again to dissipation engineering. We quantify backscattering and confirm robust propagation even around sharp bends, and image the waveguides' excitation pattern with a wide-field stroboscopic interferometer [7]. Such phonon waveguides are an elementary building block for low-loss phonon circuits with potential applications in sensing and information processing.

References

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Figures

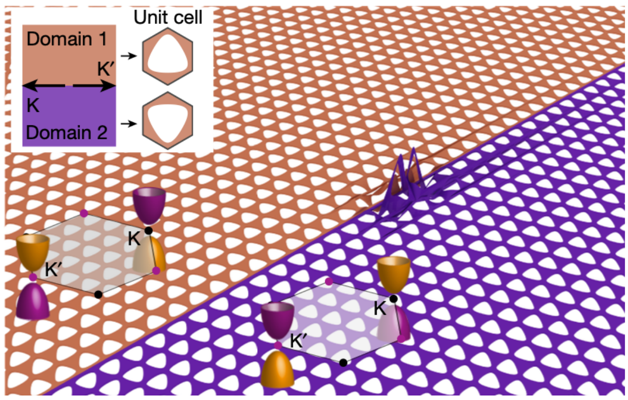

Figure 1: Illustration of a guided mode at the interface between two distinct domains of a phononic valley-Hall topological insulator [6].

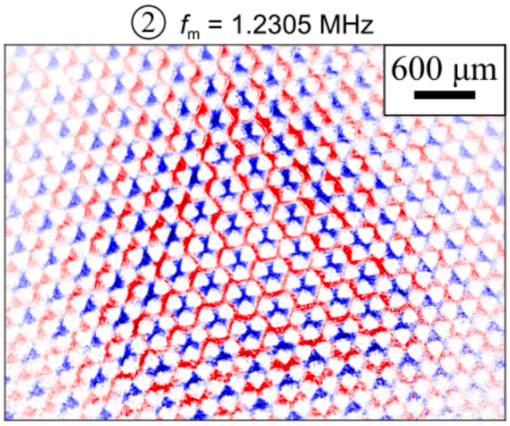

Figure 2: Displacement field of a triangular topological waveguide imaged with a stroboscopic interferometer [7].