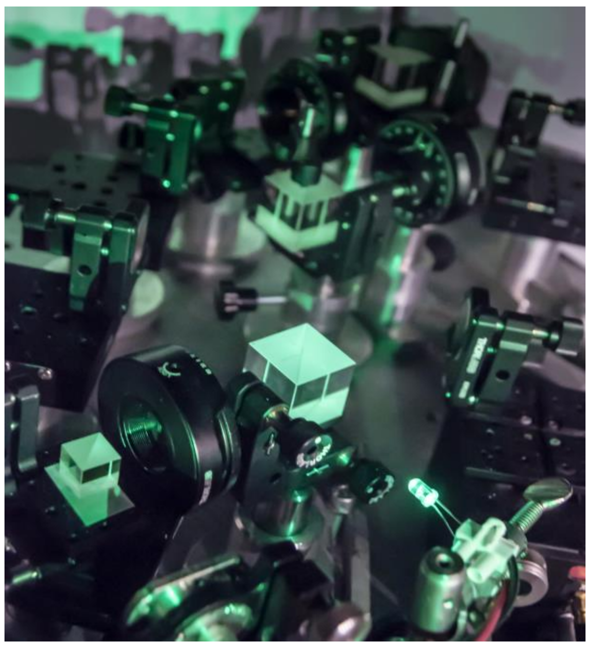
Q@TN Colloquium



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Quantum acoustic with gigahertz mechanical vibrations

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Aula A102 – Povo 1 – Via Sommarive n. 5

Abstract:

The coherent manipulation of photons – the quantum of the electromagnetic field – on a chip has enabled countless technologies, from quantum optics, metrology, and quantum computation. The basic set of tools for any of these technologies are single-photon sources and detectors, beam splitters and phase shifters. Phonons – quantum mechanical vibrations – behave similarly to photons, but with a much slower propagation speed, lower losses, and longer lifetime. Furthermore, mechanical vibrations tend to interact with many different quantum systems, such as spin, superconducting qubits, and quantum dots, to name a few. Within the field of quantum acoustic, we are trying to develop the same set of tools for phonons. This level of control could lead to new applications, such as scalable quantum computing, and provide a valuable resource for hybrid quantum technologies [1], where phonons can be used as an intermediate carrier to store and manipulate quantum information and transfer it to different systems. In this talk, I will present our team's effort towards achieving full coherent manipulation of mechanical vibrations, at the quantum-mechanical level, on a chip. Firstly, I will introduce how we generate and detect single phonons using opto-mechanical resonators [2]. Then, I will describe how to connect such resonators to phononics waveguides to route single-phonon mechanical wavepackets [3]. I will also show our latest results on a single-phonon directional coupler, which we used to successfully split single phonons with arbitrary splitting ratio [4]. Finally, I will briefly present our ongoing work on coupling our phononic nanostructures to a superconducting qubit, and how the latter can potentially be used as a deterministic source of single phonons [5].

References

[1] A. Bienfait et al., Science 364 (2019) 368-371.
[2] R. Riedinger et al., Nature 530 (2016) 313-316
[3] A. Zivari et al., Nat. Phys. 18 (2022) 789-793.
[4] A. Zivari et al., arXiv:2312.04414
[5] H. Qiao et al., Science 380 (2023) 1030-1033.

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