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Quantum electro-mechanics on dielectric nanomembranes

Abstract :

Superconducting circuits are at the focus of quantum engineering research because of their potential for scalable quantum information processing and simulation. One disadvantage of circuit QED systems is that they can only operate in ultra-cold environments where thermal noise and resistive losses are negligible. We are working towards an on-chip integrated microwave-photonic device, that has the potential to efficiently convert microwave to telecom wavelength photons using radiation pressure forces.

Utilizing compact ultra-high impedance LC circuits suspended on dielectric nano-membranes enables efficient coupling to the mechanical modes of one dimensional acoustic bandgap nanobeam resonators compatible with nano-photonics. With this new platform we demonstrate motional ground state cooling of the dielectric beam's fundamental mode, as well as mechanically mediated efficient microwave frequency conversion over 2 GHz.

Our most recent generation of devices is based on commercial silicon on insulator substrate where we just started to integrate superconducting qubits. This system should allow to synthesize and manipulate acoustic quantum states without the need for active cooling. Coupling these excitations to mechanical wave guides, entanglement between itinerant multi-phonon states could be studied in analogy to quantum optical systems. Coupling to photonic crystals on the other hand would put within reach the realization of hybrid long distance quantum communication networks.