Controlling Microwave Photons with Micromechanical Oscillators

Johannes M. Fink

Institute of Science and Technology Austria (IST Austria)

Superconducting circuits are at the focus of quantum engineering research because of their potential for scalable quantum information processing. One disadvantage of circuit QED systems is that they can only operate in ultra-cold environments where thermal noise and resistive losses are negligible. To enable larger scale superconducting quantum networks 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 nanobeam oscillators compatible with nano-photonics [1]. With our new silicon-on-insulator platform [2] we demonstrate motional ground state cooling, voltage tuneable microwave frequency conversion, superconducting qubit integration [3], the realization of highly nonreciprocal on-chip isolators and circulators [4], and the synthesis of non-classical photon states. Moving to higher frequency acoustic bandgap defined modes should allow to generate mechanical quantum states without the need for active cooling. Coupling to photonic crystals on the other hand would put within reach the realization of hybrid long distance quantum communication networks. We will present our most recent progress towards these long term goals.

References

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