Non-reciprocity and directional amplification with cavity optomechanics

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Cavity optomechanics is a rapidly-growing field in which mechanical degrees of freedom are coupled to modes of the electromagnetic field inside optical or microwave resonators. Adapting laser-cooling techniques from atomic physics several experiments have recently observed mechanical motion close to the quantum ground-state. This paves the way to exploit these systems for the engineering of phonon and photons at the nanoscale with exciting, novel applications for science and technology [Rev. Mod. Phys. 86, 1391 (2014)].

Along this line of thought, I will give an overview of recent highlights. First, I will report on the realization of a dissipative quantum reservoir for microwave light based on the reversed dissipation regime of cavity optomechanics [PRL 113, 023604 (2014)] in which dissipation of the mechanical oscillator is faster than that of the electromagnetic modes. We have exploited the engineered dissipation to implement a large gain phase-preserving microwave amplifier operating 0.87 quanta above the limit imposed by quantum mechanics [arXiv:1602.05180, to appear in Nature Physics]. Second, I will discuss the demonstration of nonreciprocal transmission between two microwave modes with optomechanical interactions only in an electromechanical circuit [arXiv:1612.08223]. Finally, I will present an implementation for phase-preserving and phase-sensitive directional amplifier in setup of two microwave cavities and two mechanical resonators [arXiv:1705.00436].