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Optomechanics: coupling optical and mechanical degrees of freedom

Objective

Cavity optomechanical systems can provide a natural platform to induce an interaction between mechanical resonators because there is an intrinsic coupling mechanism between optical and mechanical degrees of freedom. We are currently studying several aspects of this growing area of nanoscience.

Summary of Research Activities

We proposed a spectrometric method to reconstruct the motional states of mechanical modes in optomechanics [1]. We also obtained exact analytical solutions to study the coherent interaction between a single photon and the mechanical motion of a membrane in quadratic optomechanics [2]. We proposed a simple method [3] to generate quantum entanglement between two macroscopic mechanical resonators in a two-cavity optomechanical system. Moreover, we proposed how to achieve a steady-state mechanical squeezing in an optomechanical system via a Duffing nonlinearity [4].
We investigated [5] the nonlinear interaction between a squeezed cavity mode and a mechanical mode in an optomechanical system (OMS) that allows to selectively obtain either a radiation-pressure coupling or a parametric-amplification process. We also proposed and analyzed circuits [6,7] that implement nonlinear couplings between super-conducting microwave resonators. These circuits therefore allow for all-electrical realizations of analogs to optomechanical systems, with couplings that can be both strong and tunable [6,7,8].

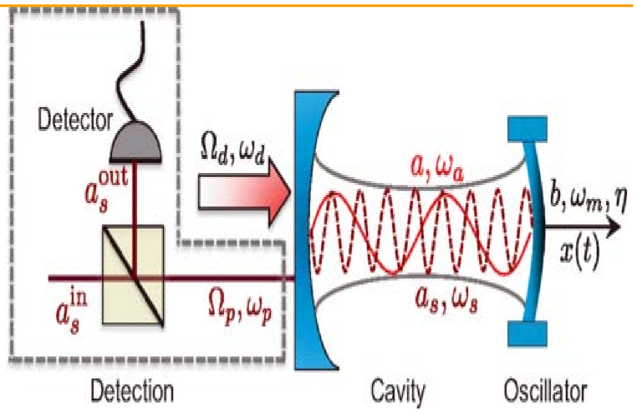

Fig. 1: Steady-state mechanical squeezing in an optomechanical system via Duffing nonlinearity [4]

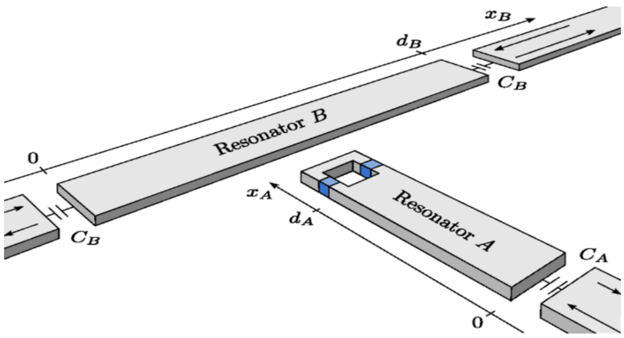

Fig. 2: Optomechanical-like coupling between superconducting resonators. [7]

Publications

[1] J.Q. Liao, F. Nori, Spectrometric Reconstruction of Mechanical-motional States in Optomechanics, Phys. Rev. A 90, 023851 (2014).
[2] J.Q. Liao, F. Nori, Single-photon quadratic optomechanics, Scientific Reports 4, 6302 (2014).
[3] J.-Q. Liao, Q.-Q. Wu, F. Nori, Entangling two macroscopic mechanical mirrors in a two-cavity optomechanical system, Phys. Rev. A 89, 014302 (2014).
[4] X.Y. Lu, J.Q. Liao, L. Tian, F. Nori, Steady-state Mechanical Squeezing in an Optomechanical System via Duffing Nonlinearity, Phys. Rev. A. 91, 013834 (2015).
[5] X.Y. Lu, Y. Wu, J.R. Johansson, H. Jing, J. Zhang, F. Nori, Squeezed Optomechanics with Phase-matched Amplification and Dissipation, Phys. Rev. Lett. 114, 093602 (2015).
[6] J.R. Johansson, G. Johansson, F. Nori, Optomechanical-like coupling between superconducting resonators, Phys. Rev. A 90, 053833 (2014).
[7] E. Kim, J.R. Johansson, F. Nori, Circuit analog of quadratic optomechanics, Phys. Rev. A 91, 033835 (2015).
[8] H. Wang, X. Gu, Y.X. Liu, A. Miranowicz, F. Nori, Optomechanical analog of two-color electromagnetically-induced transparency: Photon transmission through an optomechanical device with a two-level system, Phys. Rev. A 90, 023817 (2014).