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Laser cooling of a harmonic oscillator's bath with optomechanics

XUNNONG XU, Joint Quantum Institute, University of Maryland/National Institute of Standards and Technology, College Park, Maryland 20742, USA, JACOB TAYLOR[1], Joint Quantum Institute, National Institute of Standards and Technology, Gaithersburg, Maryland 20899, USA — Thermal noise reduction in mechanical systems is a topic both of fundamental interest for studying quantum physics at the macroscopic level and for application of interest, such as building high sensitivity mechanics based sensors. Similar to laser cooling of neutral atoms and trapped ions, the cooling of mechanical motion by radiation pressure can take single mechanical modes to their ground state. Conventional optomechanical cooling is able to introduce additional damping channel to mechanical motion, while keeping its thermal noise at the same level, and as a consequence, the effective temperature of the mechanical mode is lowered. However, the ratio of temperature to quality factor remains roughly constant, preventing dramatic advances in quantum sensing using this approach. Here we propose an efficient scheme for reducing the thermal load on a mechanical resonator while improving its quality factor. The mechanical mode of interest is assumed to be weakly coupled to its heat bath but strongly coupled to a second mechanical mode, which is cooled by radiation pressure coupling to a red detuned cavity field. We also identify a realistic optomechanical design that has the potential to realize this novel cooling scheme.

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