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Quantum cavity opto-mechanics with cold atoms: measuring and controlling a mechanical oscillator with light

DAN STAMPER-KURN, University of California, Berkeley and Lawrence Berkeley National Laboratory

In cavity opto-mechanical systems, the motion of a mechanical element is sensed by its influence on the field within an electromagnetic resonator. While their experimental realizations are quite diverse, with mechanical elements ranging from picogram-scale nanofabricated metallic filament to the kilogram-scale mirrors of the LIGO detector and optical systems ranging from microfabricated stripline resonators to kilometers-long optical cavities, such systems are converging on the common goal of realizing quantum limited operation. In this talk, I will discuss the use of ensembles of ultracold trapped atoms, with atom numbers ranging presently from 10^3 to 10^5, as mechanical elements within a high-finesse optical cavity. With this system, my colleagues and I realize cavity opto-mechanics in the quantum regime, with opto-mechanical coupling parameters that may be readily tuned and extended into a distinct granular, or strong-coupling, regime. We have also begun exploring cavity optical interactions with internal quantum variables of these atoms (their spin), and the possibilities arising from interfacing their motional and spin degrees of freedom.