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Interfacing Opto-mechanics with Atoms

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We propose and analyze setups interfacing opto-mechanical systems with single atoms or atomic ensembles. In particular we show that strong, coherent coupling between a single trapped atom and a mechanical oscillator can be mediated via a laser-driven high-finesse cavity. In free space it is still possible to achieve a coherent coupling between a micromirror and an ensemble of atoms trapped in a standing wave field reflected thereof. Finally, in a travelling wave, pulsed scheme allows for a quantum non-demolition measurement of hybrid atomic-micromechanical Einstein-Podolsky-Rosen variables. The wave function of the massive mechanical oscillator and the collective atomic spin is thereby collapsed into an entangled EPR state. These setups provide the basic toolbox for coherent manipulation, preparation and measurement of micro- and nanomechanical oscillators via the tools of atomic physics. Beyond interfaces of optomechanics to AMO systems, I will discuss general perspectives of strong and super-strong optomechanical coupling.