Cavity Optomechanics:
Manipulating the quantum state of light with a flexible mirror

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ABSTRACT:

Recent progress in the field of cavity optomechanics has demonstrated quantum behavior in
the mechanical modes of nanoscale to macroscopically sized object. For instance, mechanical
resonators have been laser cooled to near their ground state, entangled with photons, and shown to
be subject to quantum measurement backaction. Here I will present a realization of a macroscopic
continuous-measurement version of the famous Heisenberg microscope thought experiment. The
vibrational motion of a membrane mechanical resonator is interferometrically measured. The random
optical force from the shot noise of the measurement light shakes the resonator, providing the
quantum backaction necessary to satisfy the Heisenberg uncertainty relation. In this strong
backaction regime, the mechanical interaction is also useful to non-destructively measure and
manipulate the quantum state of light. We demonstrate one of the consequences of this process: the
generation of squeezed light. Establishing membrane resonators as quantum resource for the
manipulation of light opens up the possibility of mechanically interconnecting optical systems with
other quantum systems. In particular a hybrid device coupling the microwave photons in
superconducting circuit to optical photons in a cavity via a common mechanical element has the
potential to facilitate the transfer of quantum states between these otherwise incompatible elements.