Cavity Optomechanics: Exploring the coupling of light and micro- and nanomechanical oscillators
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The mutual coupling of optical and mechanical degrees of freedom via radiation pressure has been a
subject of interest in the context of quantum limited displacements measurements for Gravity Wave
Detection for many decades, however light forces have remained experimentally unexplored in such
systems. Recent advances in nano- and micro-mechanical oscillators have for the first time allowed the
observation of radiation pressure phenomena in an experimental setting and constitute the emerging
research field of cavity optomechanics[1].

Using on-chip micro-cavities that combine both optical and mechanical degrees of freedom in one and the
same device(2), radiation pressure back-action of photons is shown to lead to effective cooling(3-6) of the
mechanical oscillator mode using dynamical backaction, which has been predicted by Braginsky as early
as 1969(4). This back-action cooling exhibits many close analogies to atomic laser cooling. With this
novel technique the quantum mechanical ground state of a micromechanical oscillator has been prepared
with high probability using both microwave and optical fields. In our research this is reached using
cryogenic preccooling to ca. 700 mK in conjunction with laser cooling, allowing cooling of micro-
mechanical oscillator to only 1.7 quanta. – implying the oscillator resides more than 1/3 of its time in the
quantum ground state. Moreover it is possible in this regime to observe quantum coherent coupling in
which the mechanical and optical mode hybridize and the coupling rate exceeds the mechanical and
optical decoherence rate (7). This accomplishment enables a range of quantum optical experiments,
including state transfer from light to mechanics using the phenomenon of optomechanically induced
transparency(8).

From a broader perspective the described experiments that exploit optomechanical coupling are motivated
both by the effort to realize quantum measurement schemes on mechanical systems in an experimental
setting as well as to explore the behavior of nanomechanical systems at low temperatures.

References:
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