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Cavity optomechanics and its applications[1]

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Cavity optomechanics is an emerging field at the intersection of quantum optics, atomic physics, nanoscience and gravitational wave interferometry. It involves cavities (with one or more mechanical degrees of freedom) driven by laser radiation. The ensuing optical control of macroscopic mechanical motion may have implications for precision sensing, coherent control of atoms and molecules, and quantum information processing. Due to recent innovations optomechanical physics has been realized in a variety of experimental systems spanning many orders of magnitude in mass and time-scales. In this talk, I will first introduce the basic paradigm of a laser-driven two mirror cavity used for cooling a vibrational mode. A three-mirror configuration recently implemented using a partially transmissive dielectric membrane in a high finesse cavity will then be discussed, and shown to be superior to the two-mirror design in a number of ways. One implication of the three-mirror configuration is the possibility of scaling optomechanical techniques to multiple oscillators. This topic will be explored by analysing the case of two membranes in a cavity where it will be shown that the collective(center-of-mass and breathing) modes of vibration can be cooled independently, analogous to a chain of trapped ions. Finally, future directions for possible applications to the control of atoms and molecules will be indicated briefly.

[1]The work presented in this talk was performed at the University of Arizona, Arizona, USA, under the supervision of Prof. Pierre Meystre.