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Quantum Noise and Radiation Pressure Effects in High Power Optical Interferometers[1]

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Opto-mechanical coupling plays an important role in interferometric gravitational-wave detectors and other high-precision displacement and force measurements. In the work presented here, both theoretical and experimental studies of opto-mechanical effects and the quantum limits associated with them are performed in a variety of optical systems. Most notably, two optical fields are used to form a stable all-optical trap for a 1 gram mirror. The optical forces extract energy from the oscillator, and the oscillator is cooled to a greater degree than possible with cavity cooling or cold damping alone. The 1 gram mirror is cooled to 6.9 mK, and using a similar technique, a 2.7 kg oscillator from a LIGO interferometer is cooled to 1.4μK. The opto-mechanical techniques may also generate squeezed light, entanglement, and be used to approach the ground state of motion of the oscillator. With further improvements, these devices may allow the quantum-classical transition to be explored in macroscopic objects.

[1]The work presented in this talk was performed at MIT under the supervision of Nergis Mavalvala.