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Optomechanical cooling in an optical fiber

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Light-sound coupling mediated by radiation pressure has enabled sophisticated methods to manipulate mechanical oscillators, permitting control over mechanical dissipation, the preparation and interrogation of quantum states, and cooling of mesoscopic systems to their quantum ground state. Historically, these efforts have focused on the control of micromechanical systems. However, recently, with the advent of a new class of nano-photonic waveguide for light and sound, laser light has been used to cool bands of travelling-wave phonons on silicon chips. Here, we demonstrate this physics for first time within an optical fiber. As our system, we utilize a 1m optical fiber comprised of a silica cladding and a 450nm radius CS_2 liquid core where it is possible to achieve single mode operation for light, acoustic guidance for sound waves along the fiber core, and very large coupling between these light and sound fields. Using spontaneous backward Brillouin scattering measurements, we reveal the thermal population and effective decay rates of phonons participating in Stokes and anti-Stokes processes. These measurements show that with increasing probe power not only is the thermal population of anti-Stokes (Stokes) phonons depleted (increased) (quantified by the peak height), but the effective decay rates are altered as well (indicating how detailed balance is altered).Within this system, we reduce the temperature of a band of traveling-wave anti-Stokes phonons by 60K from room temperature, revealing that optomechanical cooling is possible in macroscopic linear waveguide systems without an optical cavity or discrete acoustic modes.