

Micromechanical resonator cooled down close to the motional ground state, and electromechanically induced microwave amplification

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The preparation and detection of mechanical vibrations near the quantum limit is a formidable challenge posed by several issues. A promising setup for the purpose is that of an on-chip microwave cavity, capacitively coupled to a nanomechanical resonator. A high electromechanical coupling energy, achieved in our setup by coupling from a flexural beam resonator via an ultranarrow 10 nm vacuum gap, facilitates operation near the quantum regime. We have prepared and observed such a 30 MHz micromechanical resonator very close to the ground state of its motion. By applying microwave irradiation to the cavity at the red mechanical sideband, we cooled the fundamental flexural mode to thermal occupancy of only 1.5 quanta. Under blue sideband irradiation associated to heating, we observe mechanical amplification of another, probe, signal applied at the cavity frequency by up to 30 dB. To our knowledge, this constitutes the first implementation of a mechanical microwave amplifier with true power gain. The changes in the absorption at the cavity frequency can be thought of as an analog of the electromagnetically induced transparency in quantum optics. A full quantum theory for the mechanical amplification is found to be in a good agreement to the experiment. The noise added by the mechanism is measured to be lower than that of a typical cryogenic microwave amplifier.

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