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Cryogenic trapped-ion system and quantum control of quantum harmonic oscillators

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We present our experimental progress on the control and application of the vibrational modes with a cryogenic trapped Calcium ions system. We implement a segmented four-blade Paul trap in a closed-cycle 4 K cryostat, achieving a heating rate of 8 phonon/s at a trap frequency of 1.1 MHz. We utilize this setup and entangle two vibration modes with reservoir engineering, and obtain a stable two-mode squeezed state along two axes. Along the squeezed axes, we demonstrate simultaneous estimation of two displacements with up to 6.9(3) dB and 7.0(3) dB improvement over the standard quantum limit, respectively. Our demonstration may have various applications, including quantum sensing, quantum imaging, and other fields that require precise measurements of multiple parameters.

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