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Spectroscopy and Thermometry of Drumhead Modes in a Mesoscopic Trapped-Ion Crystal using Entanglement[1] BRIAN SAWYER, JOSEPH BRITTON, NIST-Boulder, CO, ADAM KEITH, NCSU, Raleigh, NC, JOSEPH WANG, JAMES FREERICKS, Georgetown University, HERMANN UYS, CSIR, South Africa, MICHAEL BIERCUK, University of Sydney, JOHN BOLLINGER, NIST-Boulder, CO — Studies of quantum mechanics at intermediate scales between microscopic and mesoscopic regimes have recently focused on the observation of quantum coherent phenomena in optomechanical systems. We demonstrate spectroscopy and thermometry of individual motional modes in a mesoscopic 2D ion array using entanglement-induced decoherence as a method of transduction. Our system is a $\sim$400 μm-diameter planar crystal of several hundred $^9Be^+$ ions exhibiting complex drumhead modes in the confining potential of a Penning trap. Exploiting precise control over the $^9Be^+$ valence electron spins, we apply a homogeneous spin-dependent optical dipole force to excite arbitrary transverse modes with an effective wavelength approaching the interparticle spacing ($\sim$20 μm). Center-of-mass displacements of $\sim$120 pm are detected via entanglement of spin and motional degrees of freedom.

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