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**Broadening of the Drumhead Mode Spectrum due to In-Plane Thermal Fluctuations of Two-Dimensional Trapped Ion Crystals in a Penning Trap**[1] ATHREYA SHANKAR, CHEN TANG, University of Colorado Boulder, MATTHEW AFFOLTER, KEVIN GILMORE, NIST Boulder, DANIEL DUBIN, University of California San Diego, SCOTT PARKER, MURRAY HOLLAND, University of Colorado Boulder, JOHN BOLLINGER, NIST Boulder — Two-dimensional nonneutral plasma crystals stored in Penning traps are a leading platform for quantum simulation and sensing experiments. For small amplitudes, the out-of-plane motion of such crystals, which is exploited for quantum information protocols, can be described by a discrete set of normal modes called the drumhead modes. However, experimental observations of crystals with Doppler cooled and even near ground-state cooled drumhead modes reveal an unresolved drumhead mode spectrum. In this work, we establish in-plane thermal fluctuations in ion positions as a major contributor to the broadening of the drumhead mode spectrum. In the process, we demonstrate how the confining magnetic field leads to unconventional properties for the in-plane normal modes. These properties, in turn, have implications for the sampling procedure required to choose the in-plane initial conditions for molecular dynamics simulations. For current operating conditions of the NIST Penning trap, our study suggests that the two dimensional crystals produced in this trap undergo in-plane potential energy fluctuations in the range of 10 mK. Our study therefore motivates the need for designing improved techniques to cool the in-plane degrees of freedom.

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