Trapping and cooling of large two-dimensional ion crystals in a monolithic Paul trap

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Over the last decade, linear strings of ions have proved remarkably successful platform for quantum simulations. Scaling the system up to two-dimensional (2D) ion crystals would allow a higher number of qubits in the system and inherently enable quantum simulations of more complicated 2D spin systems. Here, we experimentally realize stably-trapped 2D ion crystals with up to 91 particles in a monolithic Paul trap, and characterize the stability of the planar crystal configurations. We implement electromagnetically-induced-transparency (EIT) cooling and show that it can be used to ground-state cool the out-of-plane modes of the 2D ion crystal. Finally, we measure the mean phonon numbers and heating rates of the 2D ion crystal, and implement a novel method for multi-ion thermometry based on the initial dynamics of the motional sidebands.

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