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Ring-shaped Wigner crystals of trapped ions at the micronscale
HAOKUN LI, ERIK URBAN, CRYSTAL NOEL, ALEXANDER CHUANG, YANG XIA, BORGE HEMMERLING, YUAN WANG, XIANG ZHANG, HARTMUT HAEFFNER, University of California, Berkeley — Trapped ion crystals are ideal platforms to study many-body physics and quantum information processing, with both the internal electronic states and external motional degree-of-freedom controllable at the single quantum level. In contrast to conventional, finite, linear chains of ions, a ring topology exhibiting periodic boundary conditions and rotational symmetry opens up a new directions to diverse topics. However, previous implementations of ion rings result in small aspect ratios (<0.07) of ion-electrode distance to ring diameter, making the rotational symmetry of the ion crystals prone to stray electric fields from imperfections of the trap electrodes, particularly evident at low temperatures. Here, using a new trap design with a 60-fold improvement of this aspect ratio, we demonstrate crystallization of $^{40}\text{Ca}^+$ ions in a ring with rotational energy barriers comparable to the thermal energy of Doppler laser cooled ion crystals. When further reducing the rotational energy barriers, we observe delocalization of the ion rings. With this result, we enter a regime where quantum topological effects can be studied and novel quantum computation and simulation experiments can be implemented.

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