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# Atomic Friction and Dynamics of Topological Defects in Ion Coulomb Crystals[1]

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Topological defects in ion Coulomb crystals (kinks) have been proposed for studies of quantum-mechanical effects with solitons and as carriers of quantum information. Defects form when a symmetry breaking phase transition is crossed nonadiabatically and the finite speed of information prevents different regions from coordinating the choice of the symmetry broken state. Where such local choices are incompatible, defects will form with densities predicted to follow a power law scaling in the rate of the transition. The importance of this Kibble-Zurek mechanism (KZM) ranges from cosmology to condensed matter. In inhomogeneous systems, the propagation of the critical front enhances the role of causality and steepens scaling of defect density with the transition rate. We use laser-cooled trapped ions in a harmonic trap to produce stable topological defects and demonstrate scaling with the transition rate across the linear to zigzag phase. Implementing mass defects and electric fields we demonstrated first steps towards a controlled kink soliton preparation and manipulation for studies of nonlinear physics in ion Coulomb crystals. Based on these findings we study the dynamics of topological defects and use them to emulate nanofriction of two atomically flat layers with back-action. With the help of phonon mode spectroscopy and high-resolution imaging we show that an ion Coulomb crystal with a defect exhibits a sticking-to-sliding transition with Aubry-type signatures. We demonstrate the measurement of the soft vibrational mode driving the transition and the order parameter, that quantifies the symmetry-breaking of the crystal configuration. Numerically we find that the soft mode frequency and the order parameter exhibit critical scaling near the transition. This model system can be used to investigate the tribological behaviour of self-organized structures in the classical and in the quantum regime.

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