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Hot and Cold Dynamics of Trapped Ion Crystals near a Structural Phase Transition

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Small arrays of laser-cooled trapped ions are widely used for quantum information research, but they are also a versatile mesoscopic system to investigate physics with a flavor reminiscent of familiar models in condensed matter. For example, in a linear rf Paul trap, laser-cooled trapped ions will organize into a linear array when the transverse confinement of the trap is strong enough; however, at a critical trap anisotropy the ions will undergo a symmetry–breaking structural transition to a two-dimensional zigzag configuration. We have studied what is effectively the melting behavior of the ion arrays near to the linear-zigzag transition. We have also investigated the classical non-equilibrium dynamics during rapid quenches of the transition in order to test the Kibble-Zurek mechanism of topological defect formation across a symmetry-breaking transition. In this talk I will present our current investigations of dynamics near the linear-zigzag transition at ultralow temperatures, corresponding to just a few quanta of thermal energy in the vibrations of the ion array. I will discuss our implementation of a new laser cooling technique for trapped Ytterbium ions and our progress towards experiments in the quantum regime. For example, we are interested in whether decoherence effects can be sufficiently suppressed to prepare superpositions of the symmetry-broken configurations.

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