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Towards Quantum Double-Well 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 organize into a linear array when the transverse confinement of the trap is strong enough; however, at a critical trap anisotropy the ions undergo a symmetrybreaking structural transition to a two-dimensional zigzag configuration. I will discuss our current investigations of dynamics near this linear-zigzag transition at ultralow temperatures, corresponding to just a few quanta or less of thermal energy in the vibrations of the ion array. The second-order nature of the linear-zigzag transition, and the resulting double-well potential that develops as the transition is crossed, offer the possibility to explore a variety of quantum effects, in particular tunneling phenomena near the critical point. We are interested to see whether superposition states of the zig and zag symmetry-broken configurations can be prepared, and how the decoherence of such states depends on the number of ions.