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Quantum Double-Well Dynamics of Trapped Ion Crystals near a Structural Phase Transition

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In a linear radio-frequency Paul trap, relaxing the transverse confinement beyond a critical value will cause laser-cooled, trapped ions to undergo a symmetrybreaking structural transition from a linear to a two-dimensional zigzag configuration. I will discuss our current investigations of dynamics near this linear-zigzag transition at temperatures corresponding to a few quanta or less of thermal energy in the vibrations of the ion array. The second-order nature of the ideal linear-zigzag transition, and the resulting symmetric double-well potential that develops as the critical point for the transition is crossed, offer the possibility to explore a variety of quantum effects, in particular tunneling phenomena near the critical point. Using Raman sideband techniques, we probe spectroscopically the shape of the double well and assess the decoherence near the transition for our system of Yb^+ ions in a four-rod linear Paul trap. We are ultimately 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.