Control of ion crystals for atom-ion quantum mixtures

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Abstract: This presentation details advancements in combining Ba^+ ions with ^6Li gases, featuring the integration of a Paul and an electro-optical trap. These innovations enable dynamic control of the trap for studying two-dimensional ion crystals.

In the presentation, the most recent advancements in the realization of an experimental setup combining trapped Barium ions with fermionic Lithium gases will be presented. In the design of our apparatus, we have conceived several technical innovations aimed at improving control over the atom-ion quantum mixture.

In particular, we have designed a bow-tie cavity for the generation of a deep optical lattice potential that can confine both the atoms and the ions in a two-dimensional pancake-shaped trap [1]. This potential has the advantage of making it possible to control both the density of the atoms and the shape of the ion crystal. Specifically, by changing the DC potential confining the ions within one lattice site, it will be possible to produce one-dimensional or two-dimensional crystals. This electro-optical trap is embedded with a Paul trap, which was designed in order to maximize the trap matching between the two confining potentials and facilitate a smooth transfer of the particles between the two traps. To this end, the endcaps of the Paul trap were designed as negatively-charged electrodes pointing at the center of the trapping volume. The specific geometry of these traps [1] makes it possible to continuously change the arrangement of the ions from a one-dimensional string to a two-dimensional crystal, and to study specific phenomena in two-dimensional crystals of ions, such as the occurrence of orientational melting [2], and the formation of metastable crystal configurations that are not thermodynamically stable [3].

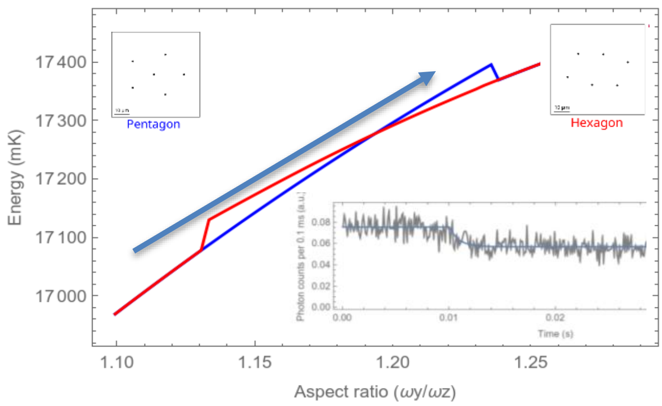

Fig. 1 Observation of metastable crystals of ions. The thermodynamic ground state structure of a two-dimensional crystal of 6 ions changes from a hexagon to a pentagon shape depending on the trap aspect ratio. Inset: when the aspect ratio is rapidly changed, the crystal's structure can hold on an "isomeric" excited state until it decays to the thermodynamic ground state due to thermal fluctuations.

References

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