Laser cooling of Ca^+ ions in a cryogenic linear rf octupole ion trap

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A cryogenic linear rf octupole ion trap was applied to a laser-cooling experiment of Ca^+ ions for the first time. The phase transition of laser-cooled Ca^+ ions has been confirmed by observation of a laser-induced fluoresecence (LIF) spectrum (Fig1a). The shapes of the Coulomb crystals and the translational temperature of the Ca^+ ions were deduced by molecular dynamics (MD) simulation. Due to small rf heating effect in a multipole ion trap[1], a new feature of the Coulomb crystal, that the crystal in a linear Paul trap does not have, is expected. The simulation shows that for a small number of ions a ring-shaped ion-crystal is produced. We have also performed a numerical simulation of sympathetic cooling of molecular ions with the purpose to apply the study of ion-molecule reactions at very low temperatures. It was found that the translational temperature of the sympathetically cooled NH_3^+ ions can be cooled to below 15 K by laser-cooled Ca^+ ions (Fig.1b). These results show that cryogenic linear multipole traps are good tools for studying Coulomb crystals, sympathetic cooling of molecular ions and ion-molecule reactions at very low temperatrures.

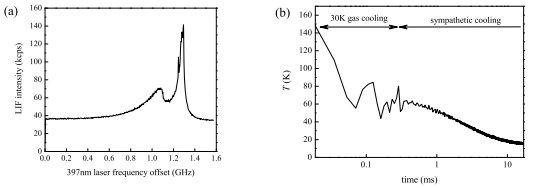

Figure 1: *(a) LIF spectrum of laser-cooled Ca^+ ions in a cryogenic linear octupole ion trap. The abrupt dip of the spectrum, characteristic of the phase transition of the ions, was observed. (b) MD simulation of sympathetic cooling of 6 NH_3^+ ions by laser-cooled 12 Ca^+ ions in a octupole linear rf trap.*

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