Towards precision laser spectroscopy with cold highly charged ions

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Laser spectroscopy with highly charged ions (HCI) enables studies of QED, relativistic and nuclear size effects which follow charge-dependent scaling laws. Narrow optical transitions found between fine structure levels in HCI are of great interest for investigations of possible variations of the fine structure constant α [1] and for realisations of high accuracy frequency standards. Optical clocks based on such transitions will benefit from a low susceptibility to external fields which largely suppresses systematic shifts. Moreover, strong relativistic effects enhance their sensitivity to possible α drifts. Electron beam ion traps (EBIT) have recently enabled optical laser spectroscopy with trapped HCI [2, 3]. However, typical translational temperatures higher than 10^5 K of the HCI trapped in an EBIT severely limit the achievable resolution. To overcome this, our cryogenic linear Paul trap CryPTEx [4] will enable trapping and sympathetic cooling of a wide range of EBIT-produced HCI by means of Be^+ ions laser-cooled into Coulomb crystals. Achievable ion temperatures on the order of mK will give access to the natural linewidth of forbidden optical transitions in HCI on the order of tens of Hz. A recently commissioned deceleration beamline with time-focusing properties for efficient ion extraction and injection feeds CryPTEx with HCI extracted from an EBIT and Be^+ Coulomb crystal studies (Fig. 1) have been performed. The slowing down and capturing of HCIs (in particular Ar^{13+}) in Be^+ Coulomb crystals is the next step. Additionally, a narrow-linewdith laser system based on a Ti:Sa laser is currently being developed, which will span most of the visible spectrum for high precision laser spectroscopy of HCIs.

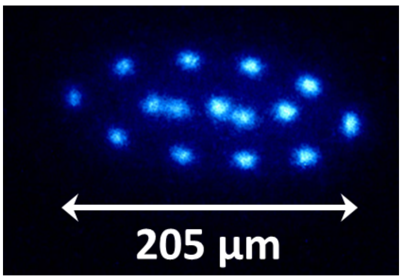

Figure 1: *Small Be^+ Coulomb crystal obtained with axial and radial trap frequencies of $97 \times 2\pi$ kHz and $365 \times 2\pi$ kHz, respectively.*

References

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