HILITE - High-intensity laser experiments on stored ions

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Synopsis We present a Penning-trap experiment for detailed investigations of the interaction of atomic or molecular ions with high-intensity laser fields. Such fields induce non-linear optical processes such as field ionization and multi-photon ionization, which can be studied over a broad range of laser parameters. The setup allows advanced ion target preparation, non-destructive product analysis and is designed to be operated at different large-scale laser facilities.

The HILITE experiment aims at studies of the behaviour of atomic and molecular systems in extreme electromagnetic fields. This is realized by the preparation and confinement of atomic and molecular ion targets in a Penning trap, and the non-destructive analysis of reaction products upon interaction with high-intensity laser light. For a determination of absolute reaction cross sections, it is crucial to identify and count both the educts and products. Therefore, we have designed and built the HILITE (High-Intensity Laser Ion-Trap Experiment), which employs several Penning-trap techniques for ion capture, confinement, selection and ion-target formation. To cover a broad range of laser parameters it is necessary to have access to different laser sources. The setup is hence built in a compact fashion which allows it to be moved easily from one location to the other. The main focus concerning measurement performance lies on versatility and reliability.

The trap electronics is located in the bore of a 6 T superconducting magnet. The trap itself located in the centre of the magnetic field, where the homogeneity is better than 10 ppm. The trap is a cylindrical open-endcap design with access from both sides for incoupling of the laser beam and ion injection from an external source. In order to achieve long ion storage times the design residual gas pressure is better than 10^{-12} mbar. To compromise this open design with a sufficient vacuum in the interaction region, a set of baffles at cryogenic temperatures is applied on each side of the trap-electrodes. Furthermore we use one set of baffles as a single-pass charge counter to characterize the ion bunches entering and leaving the trap. Another set of baffles is used as a pulsed drift tube to decelerate ions for dynamic capture of externally produced ions, for example from an EBIT or a beamline.

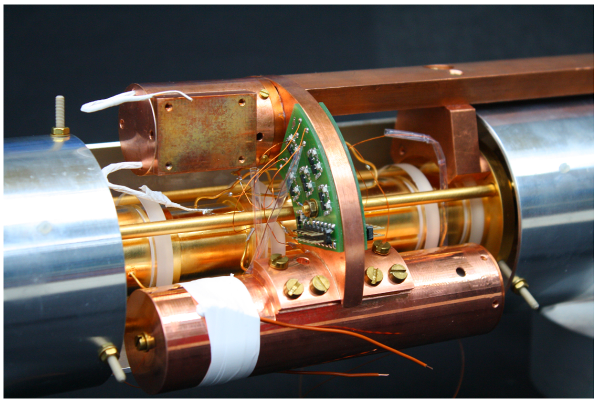

Figure 1. Photographic image of the assembled Penning trap - electrodes inside inner tube with applied filter boards, cryo-amplifier and resonators.

For non-destructive ion detection we use resonant amplification of mirror currents induced in the trap electrodes by the ion oscillations. By tuning the trap potential, this allows to measure charge-to-mass ratio spectra of the confined ions over a broad range. To be also sensitive to a small ion numbers, we apply a destructive measurement technique. Using a MCP-detector-system with a timing anode we are able to measure even single ions, when ejecting the reaction products out of the trap.

We present the current status of the experiment and the results of the characterization experiments of our ion trap. We also give an outlook to the foreseen laser-ion experiments and their scientific benefits.

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