The HILITE Penning trap experiment

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We have built a dedicated Penning trap setup for the preparation of suitable ion targets for irradiation with high-intensity laser light, and the study of subsequent reactions. Of particular interest is the detailed investigation of multiphoton-ionisation of confined particles by highly intense laser light. One important aspect is control over the confined particles' mass, charge, density, localization and optimized overlap with the laser light by Penning trap techniques like the use of trap electrodes as 'electrostatic tweezers' and by application of a 'rotating wall', respectively [1]. Also, the non-destructive detection of reaction products is a central property. The Penning trap setup is designed in a portable fashion, such that it can be attached to existing laser systems easily, see figures 1 and 2.

The interaction of highly intense radiation with matter and the corresponding non-linear effects have been subject of lively research, both theoretical and experimental, especially in the infrared and visible photon energy regimes. Laser systems capable of producing high intensities also at photon energies in the extreme ultra-violet (EUV) and (soft) X-ray regime open access to novel effects like non-linear Compton effects or simultaneous elastic and inelastic photon scattering, and allow multiphoton-ionisation experiments in a new domain. However, experiments have so far not been able to prepare and investigate well-defined particle ensembles and to non-destructively analyse the reaction products with high accuracy, nor were they able to select or prepare products for further studies in a well-defined way.

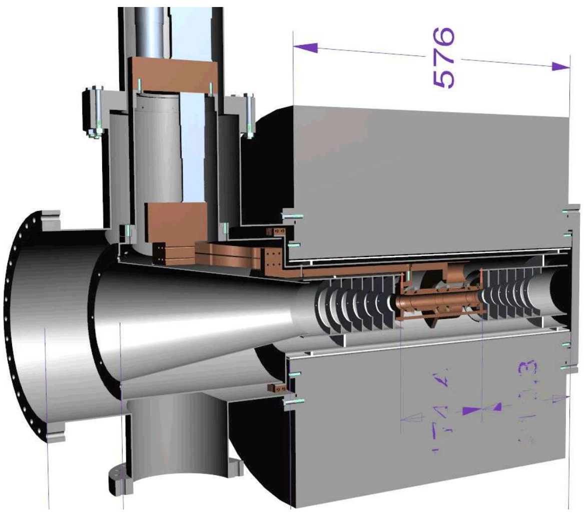

Figure 1: Cut through the HILITE setup in its current state with the Penning trap in the centre of the superconducting magnet.

The particles (atomic or molecular ions) are confined in the Penning trap following in-trap production or capture of externally produced ions. Confined ions can be cooled, compressed, positioned and selected with respect to their mass and charge prior to laser irradiation. The reaction products are analysed by non-destructive methods and hence remain confined for further studies. Such measurements are, for example, able to determine cross sections for multiphoton-ionisation in an energy- and intensity- regime so far not or not sufficiently examined. Additionally, the created electrons may be extracted from the trap and analysed externally. Hence, the reaction energetics may be reconstructed as completely as possible.

Figure 2: Photograph of the HILITE superconducting magnet setup currently located at the HITRAP facility.

We have completed the vacuum system and thermal radiation shielding which hosts the Penning trap inside the magnet bore, and cooled it to cryogenic temperatures using a two-stage cryo-cooler. The magnet has been operated at fields up to 6 T and the vacuum system has successfully been tested to leak rates below the 10^{-10} mbar l/s scale. We will now focus on the operation and detection electronics as well as on connectivity to an external (EBIT) ion source for highly-charged ions.

References

[1] M. Vogel, W. Quint, Th. Stöhlker and G.G. Paulus, Nucl. Inst. Meth. B **285**, 65 (2012).

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