HILITE - A Penning trap for experiments on trapped ions with intense laser pulses

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In collaboration with the GSI in Darmstadt we have constructed a Penning trap for laser ionisation of trapped ions at extreme intensities. Inside a Penning trap ions are stored using a superposition of a strong magnetic field (6T) and a quadrupolar electric field. It is thus possible to control the characteristics of an ion-cloud with regard to ion density, shape and charge-state. The trap enables us to determine the stored charge-states non-destructively and to estimate their number - both before and after laser-interaction. By this method we will precisely determine the laser ionisation cross section. It is possible to non-destructively detect all charge-states of all nuclides up to Xenon. In order to be independent from any accelerator infrastructure we use as ion source a so-called electron beam ion trap (EBIT), that can produce ions at high charge states (e.g. Ar\textsuperscript{16+}). With the help of ion optics the ions are injected into the trap, slowed by a so-called pulsed drift tube and captured.

The setup was constructed to be transportable. The measurements are (300 x 70 x 200) cm at a mass of less than 700 kg for the complete setup, which can be split up into three smaller modules. We plan to combine the trap with different laser setups like POLARIS and JETI in Jena or FLASH in Hamburg. In this way we will be able to cover a broad spectrum of ionisation parameters.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Complete set-up including EBIT, Wien filter laser beam-dump, cryogenic magnets with ion trap and laser window (from left to right)}\end{figure}
Figure 2: Experimental principle: Stored ions in the center of the trap are ionized further by a focussed intense laser. The brown electrodes are used to decelerate the ions entering the trap.

Figure 3: Penning trap with radial and axial resonator for non-destructive particle detection

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Related literature:

[1] A Penning trap for advanced studies with particles in extreme laser fields

Background information:

[2] Extreme Ultraviolet Laser Excites Atomic Giant Resonance

[3] Dynamics of laser-cooled Ca+ ions in a Penning trap with a rotating wall