Versatile cold atom apparatus

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We present a compact apparatus that consists of a cold atomic target at the center of a high resolution recoil ion momentum spectrometer (RIMS) [1] which will be implemented in the HITRAP beamline at GSI.

With our current setup densities of up to a few 10^{11} atoms/cm^{-3} can be achieved. Therefore a dark spontaneous force optical trap [2] loaded by a 2D MOT [3] is used which not only overcomes the density limit of a normal magneto optical trap but also reduces loading times of the trap to as low as 300ms. This allows measurements of processes with very low probability such as multi electron charge transfer, which are otherwise disguised by the far more dominant single charge transfer channel. To resolve the dynamics of such processes a new recoil ion momentum spectrometer has been build (Fig. 1).

The whole setup has been tested using a pulsed laser beam. The inset of Fig. 1 shows the recoil ions' angular momentum distribution depending on the polarization of this pulsed laser. It can be clearly seen that the very small momentum transferred to the ion during the ionization process can be well resolved. The determined resolution of the recoil ions' momentum is 0.10 a.u. which is sufficient to study multiple charge transfer in highly charged ion – atom collisions. With these measurements also the target could be characterized in great detail and the use of the 2D MOT as an independent target has been explored [4].

As a next step the target will be upgraded by implementing a dipole trap where the atoms are trapped at the focus of a far detuned, intense laser beam. This technique allows the reach densities of some 10^{13} atoms/cm^{-3} and by letting the warmest atoms evaporate from the trap a Bose-Einstein-Condensate (BEC) can be reached. This way a completely new target will be provided where not only the interactions between single atoms and ions but also collective effects which are only present in BECs can be investigated.

In addition, using a dipole trap allows to trap atoms without the use of a magnetic field which has several advantages. Firstly the trap can be run continuously whereas in the present setup the magnetic field as well as the MOT lasers have to be switched of several milli-seconds before any recoil momentum can be measured with high accuracy. Secondly it is possible to state prepare the atoms in the dipole trap which makes it possible to explore the dependence of multiple charge transfer on the polarization of the target.

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References

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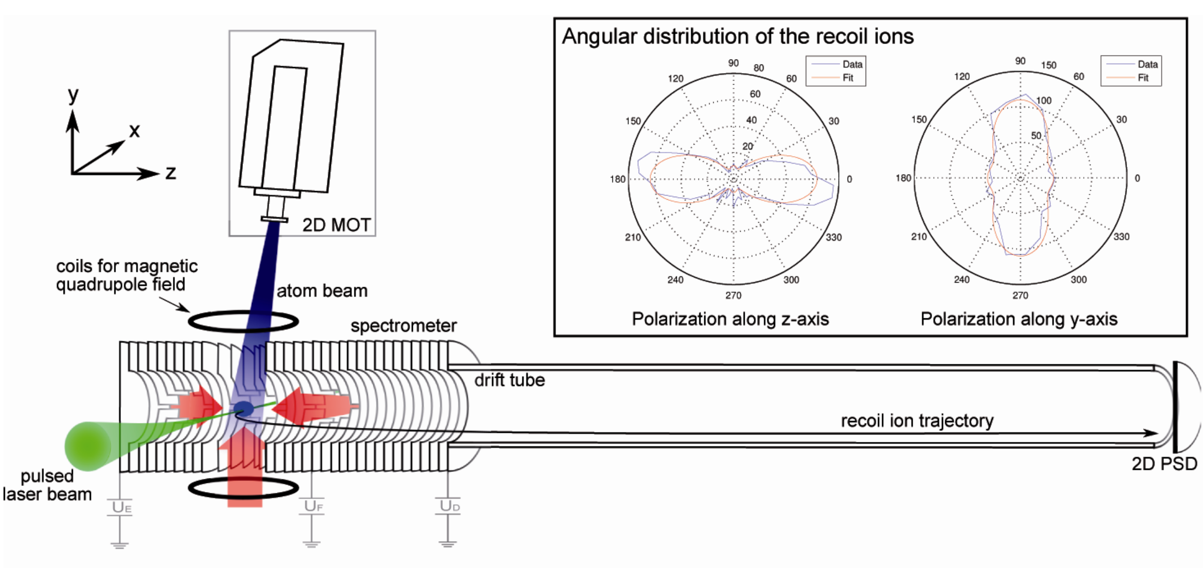

Figure 1: MOTRIMS setup. The inlet shows the recoil ions' angular momentum distribution when atoms are photoionized with a pulsed laser beam. The two graphs correspond to the different polarizations of the laser.