Radiative processes studied for bare uranium ions in collisions with the H_2 target of the ESR*

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It was previously shown [1] that for high-Z systems the elementary process of photoionization is studied best in inverse kinematics by utilizing its time-reversed reaction, the radiative electron capture (REC) in energetic ion-atom collisions. For studying these processes the internal gas target of the ESR storage ring has been shown to provide an unique tool [2].

The experiment was performed in the ESR by using decelerated bare uranium ions at an energy of 96.6 MeV/u. In the interaction chamber of the gas target, projectile x-rays were produced in collisions with H_2 molecules. By using liquid nitrogen cooling, a density of about $2 \cdot 10^{12}$ particles per cm^3 was reached. The emitted photons were detected by an array of solid state detectors at 10°, 35°, 60°, 120° and 150° with respect to the beam axis. After passing the target chamber, the down-charged ions were separated from the beam by a dipole magnet and afterwards detected by a Multi Wire Proportional Counter (MWPC) located at the outer side of the ring.

By using the coincidence technique described in [3] we obtained the spectrum shown in figure 1. The spectrum contains several lines arising from REC into projectile K-shell, the L-subshells, and the M-shell. Even REC into the N-shell appears to be well resolved from O- and higher shells demonstrating the superior resolution achieved in this study. Electron capture into the excited states leads to the characteristic Lyman transitions, appearing well pronounced in the spectrum (Ly-α and Ly-β lines).

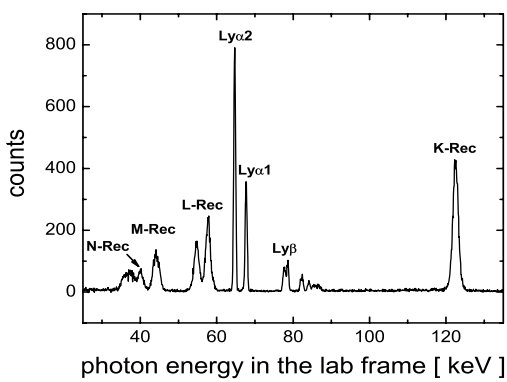

Figure 1: X-ray spectrum observed at 150 degree in the lab frame in coincidence with down-charged projectile ions.

As an example, in figure 2 the measured cross sections for REC into a) the $1s_{1/2}$ and b) the $2p_{3/2}$ state are presented for various angles in the laboratory frame. The results were normalized and compared to fully relativistic calculations (dashed lines). As can be seen in the figure, the measurements are in very good agreement with the theoretical predictions.

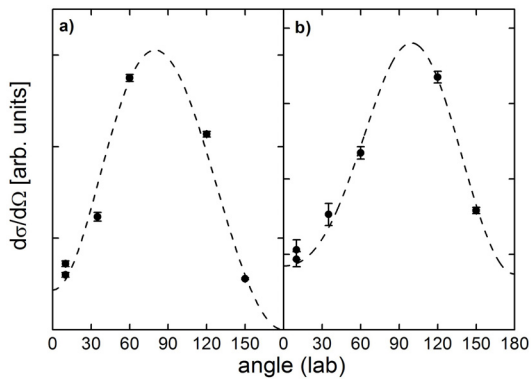

Figure 2: Measured relative REC cross sections (dots) for various angles in the lab frame in comparison to fully relativistic calculations (dashed lines): a) REC into the $1s_{1/2}$ state; b) REC into the $2p_{3/2}$ state

Recapitulating, in the present experiment the cooled hydrogen target at the ESR storage ring proofed its ability of a stable long time performance. As the experimental resolution for radiative processes occurring in heavy ions atom collisions such as REC depends essentially on the target electron momentum distribution (Compton profile), the use of hydrogen is of particular advantage. Thereby, an excellent resolution has been obtained for the REC transitions, which even allowed to distinguish REC radiation for the N- and M-shells.

References

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