Radiative Processes Studied in Collisions of Decelerated Bare Uranium Ions with H_2 Target

A. Gumberidze[1,2], Th. Stöhlker[1,2], S. Hagmann[1,2], S. Hess[1,2], C. Kozhuharov[1], U. Popp[1], R. Reuschl[1,2], J. Rzadkiewicz[1,3], U. Spillmann[1,2], S. Trotsenko[1,2], G. Weber[1]

[1]GSI, Darmstadt, Germany, [2]University of Frankfurt, Germany, [3]IPJ Swierk, Poland

Projectile X-ray emission arising from collisions of high-Z ions with the gas-target atoms and molecules has proven throughout the years to be a unique tool for accurate studies of atomic structure and dynamics in the domain of extreme electromagnetic fields. The ideal conditions offered by the ESR storage ring along with the internal gasjet target enables for detailed investigations of various fundamental atomic processes occurring in the ion-atom collisions. In the present experiment, the X-ray emission study was carried out for collisions of bare uranium (U^{92+}) ions with the H_2 gas target at the beam energy of 98 MeV/u. Here, we like to emphasize that the H_2 gas target was used for the first time since its commissioning in 2001 [1] and offered an improved performance, in particular a better long-term stability. The use of hydrogen as a target provides many advantages with respect to beam lifetimes and also spectroscopic resolution due to a very narrow Compton-profile. For the x-ray recording, the experimental chamber at the ESR gas target was utilized. The x-rays were measured by an array of Ge(i) detectors mounted at different observation angles with respect to the beam. In Fig. 1, we present x-ray spectra as recorded by the detector at 150 deg. Exploiting a coincidence technique (with the down-charged ions), two different radiative processes can be rigorously identified/separated; the Radiative Electron Capture (REC) into the bare uranium ions (b) and the Bremsstrahlung stemming from inelastic scattering of initially bound target electrons by the nucleus of the projectile (c). The latter process is of particular importance since up to now only few experimental studies have been conducted for such collisions [2]. In addition, the case of bare ions attracts the greatest interest since here the interaction of the electrons with the pure Coulomb potential of the projectile can be studied in the absence of many-body effects. Therefore, the reliability of theoretical models can be most precisely examined in such experiments. In particular, high-Z projectiles are of interest, as they exclusively probe the coupling between the continuum states and the radiation field in the presence of strong external potentials. Moreover, the tip region is very clearly identified in the experiment, (Fig.1 c)) owing to the very narrow Compton-profile of the target electron. The shape of the spectrum near to the tip is, in particular, sensitive to Coulomb distortions caused by the large nuclear charge of the projectile. Besides, this hard-photon bremsstrahlung is closely related to the REC, i.e. the time-reversed Photo Effect and therefore, its study is complementary to the investigations of the REC extending them to final electron states of positive energy.

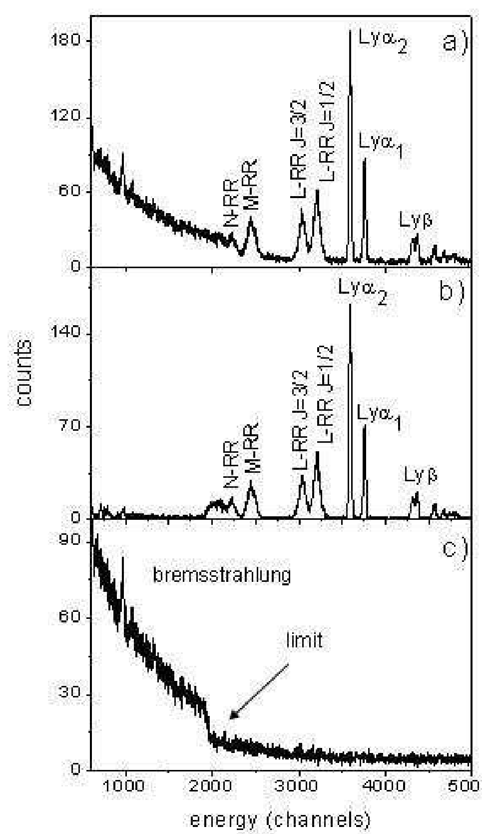

Fig 1; a) Total x-ray spectrum from $U^{92+}\rightarrow H_2$ collisions at 98 MeV/u, b) x-ray spectrum acquired in coincidence with capture of one electron into a projectile ion, c) difference between the total spectrum and the coincident one; corresponding to collisions where no charge exchange took place.

Acknowledgements

This work has been supported by I3 EURONS under EC contract No. 506065.

References

[1] A. Krämer et al., NIM B, 174, p205, 2001.
[2] T. Ludziejewski et al., J. Phys. B, 31, p2601 1998.