Search for Correlated Electron Capture in Relativistic U^{92+} Collisions

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Double photoionization of two-electron systems is a key process for the study of correlation effects in atomic multi-body systems [1]. Collision experiments with bare ions provide us with the unique possibility to study this effect under time reversal conditions, i.e. correlated capture of two electrons via simultaneous emission of one single photon (RDEC - Radiative Double Electron Capture) [2].

At the jet target of the ESR storage ring several experiments have been performed to identify this process in collisions of bare uranium ions with gaseous matter. So far, however, this process has not been confirmed experimentally.

During a recent uranium beam time at the ESR, a new attempt has been undertaken by using a considerably improved experimental setup. The main intention of this experiment was to detect RDEC photons in coincidence with double charge exchange, the signature of this particular process. For this purpose, projectile photon emission was observed simultaneously at various observation angles. Compared to the former experiments the overall photon efficiency could be enhanced by almost two orders of magnitude.

In the experiment bare uranium ions at an energy of 297 MeV/u bombarded a thin Ar-target. The target area has been viewed by an array of x-ray detectors [3] gated with signals from the particle detector mounted behind the bending magnet, next to the gas-jet target. The trajectory of the circulating ion beam was especially tuned in order to enable the registration of ions, which captured two electrons.

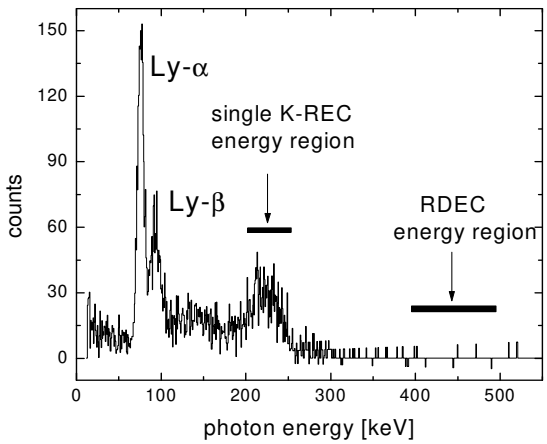

Fig. 1: *X-ray spectrum (corrected for random events and detector efficiency) measured at 90° in coincidence with double charge exchange. A REC line for photons with a single K-REC energy associated with double electron capture is clearly observed.*

A sample x-ray spectrum measured at 90° in coincidence with double charge exchange is depicted in Fig.1. A REC line for photons with the single K-REC energy, associated with double electron capture, is clearly observed. However, within the energy region relevant for RDEC, only a few events have been detected and no x-ray line shows up. From the present state of the data analysis we can already conclude that the cross section of this extremely rare process is below 10 mb. This is in contradiction to the presently available theoretical predictions, concerning relativistic effects [4].

Tab. 1: *Capture cross-sections*

capture	experimental value [barn]	theoretical predictions [barn]	
		nonrelativistic	relativistic
RDEC	$<10^{-2}$	$5\cdot10^{-6}$	5

Simultaneously, the total cross-section for double electron capture was measured and amounts to 400±70 mb. In addition, the angular distribution of single K-REC photons, associated with double charge exchange, was registered. We realise that the corresponding emission pattern (Fig.2) is similar to that for K-REC photons measured in coincidence with single electron capture [3].

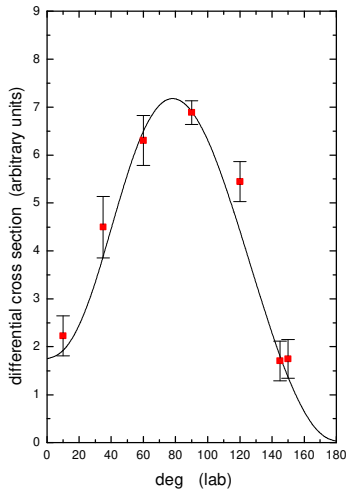

Fig. 2: *Angular distribution of photons with single K-REC energy associated with double electron capture. Solid line – full relativistic description for K-REC associated with single electron capture normalised to the experimental data.*

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