Double Charge Exchange in Relativistic U^{92+} Collisions at the ESR Gas-Jet Target

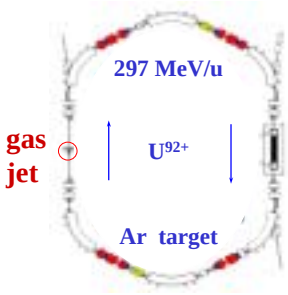
G. Bednarz[1], D.Sierpowski[1], Th. Stöhlker[2], A. Warczak[1], H. Beyer[2], F. Bosch[2], A. Bräuning-Demian[2], H. Bräuning[2], X. Cai[3], A. Gumberidze[2], S. Hagmann[2], C. Kozhuharov[2], D. Liesen[2], X. Ma [3], P.H. Mokler[2], A.Orsic-Muthig[2], Z. Stachura[4], S. Toleikis[2]

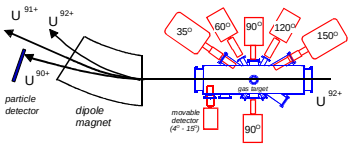
[1] *IFUJ-Krakow (Poland),* [2] *GSI-Darmstadt (Germany) ,* [3] *IMP-Lanzhou (China),* [4] *INP-Krakow (Poland)*

Multi-electron capture processes observed in relativistic collisions of fully stripped heavy ions open an insight into electron-electron correlation phenomena in strong fields.

The main intention of the present experiment was to observe processes associated with correlated capture of two electrons into bare uranium ions. The angular distributions and total cross sections were studied.

Experimental set-up at the ESR

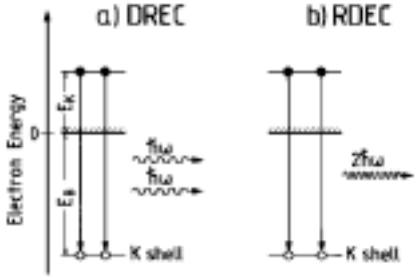




The measurements were performed at the ESR storage ring at GSI Darmstadt.

The supersonic jet-target allowed to observe projectile x-ray emission at various observation angles in the range between ≈ 0^0 to 150^0 with respect to the beam axis.

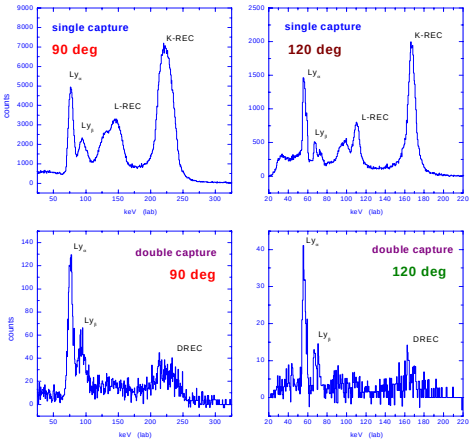
Processes related to double electron capture



• double radiative electron capture (DREC) – a two-step process in which two uncorrelated electrons are captured in one collision and two photons are emitted, both with the energy of single REC photons.

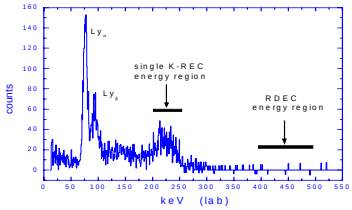
• radiative double electron capture (RDEC) – a one-step process, where the energy and momentum gained by capture of two correlated electrons is converted into one photon with twice the energy of single REC photons. In analogy to REC, the RDEC can be treated as time reversal of double photoionization.

The spectra associated with single and double electron capture



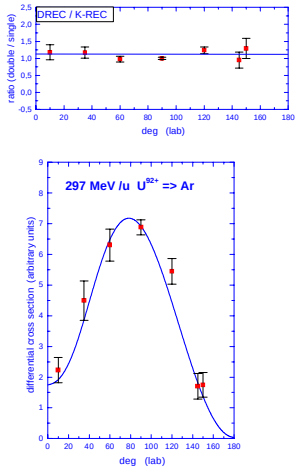
• the double electron capture spectra are strongly dominated by the characteristic lines of the projectile, in contrast to the single electron capture spectra.

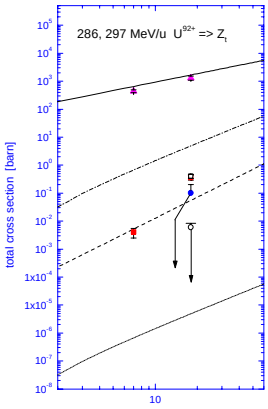
• the width of the K-REC line associated with capture of two electrons is assumed to be a factor of two larger than the width of the K-REC line related to capture of one electron.



• in the high-energy part of the spectrum taken in coincidence with capture of two electrons, no RDEC line [1] (twice the energy of the single K-REC) can be seen.

Angular distribution of K-REC radiation associated with double electron capture and total cross sections measured in the experiment





Theoretical predictions:
line: solid - REC;
dashed - DREC;
dotted - RDEC (n.rel);
dash-dotted - RDEC (rel.).

Experiment:
triangles - single capture;
squares - double capture;
circles - RDEC estimate.

• observed single K-REC photons associated with single and double electron capture show similar angular distribution.

• upper limit of 8 mb for the cross-section was obtained from few counts collected in the energy region related to the correlated two-electron REC. This limit is in contradiction to the available theoretical predictions [2].

References:

[1] A. Warczak et al., Nucl. Instr. Meth, **B 98**, 303 (1995).
[2] V.L. Yakhontov, M.Ya Amusia, Phys. Rev. **A 55**, 1952 (1997).
[3] G. Bednarz et al., Physica Scripta **T 92**, 429 (2001)