Higher-ordered recombination processes investigated with UJ-EBIT

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In Highly Charged Ions Laboratory in the Institute of Physics of the Jagiellonian University, an electron beam ion trap (Dresden EBIT [1], DREEBIT Co.) was installed a few years ago for teaching purposes mainly. However, this compact room-temperature HCI-trap, equipped with an x-ray detector (XFlash 5030, Bruker Co.), opens a wide range of possibilities for studies of atomic processes associated with ion production and trapping in an EBIT [1]. Our starting experiments were dedicated to the most simple type of recombination process, called radiative recombination (RR). The capture of a free electron into a bound state of an ion is accompanied by the emission of a photon. Resonant recombination involving more than one electron has also been already explored in our laboratory. The most basic of these resonant processes is dielectronic recombination (DR) where a free electron is captured into a bound state of an ion with the simultaneous excitation of a core electron [2, 3]. These resonantly populated excited states decay via characteristic K-shell X-ray emission. The UJ-EBIT experiments showed that spectra generated from K-LL resonances enables the K-LL DR resonances to be distinguished for He- up to N-like Ar ions. In this region, in addition to the K-LL DR, one of the $2p_{1/2}$ subshell electrons was excited to the $2p_{3/2}$ subshell state. Thus, a significant influence of the **intershell TR process** (KL-LLL) was observed [2].

Those results encouraged more detailed present studies of TR, specifically KK TR. There, the resonant capture of a free electron to an ion-bound state transfers two K-shell electrons to a higher atomic shell. This way, a doubly-excited Ar-K state, obtained via TR, decays by a hypersatellite transition and by a subsequent satellite transition yielding either $K_\alpha{}^h$ or $K_\alpha{}^s$ radiation, respectively [3]. In Figure 1 the ratio of $K_\alpha{}^h/K_\alpha{}^s$ lines for two ionization time periods is shown. In this case, the data taking time was relatively long (ca. 72 h for each data point). This results suggests the presence of a process which favors double K shell excitation. This way, TR may be one of the possible processes responsible for this enhancement. The dominant argument for this conclusion is delivered by the observed strong enhancement of the Kαh line in the predicted electron energy region. The variation of ration presented on Figure 1 suggest that in the investigated case we observe a convolution of KK-LLL, KK-LLM and KK-LMM for different charge states of Ar ions.

This **TR process has been not reported yet** to the best of our knowledge. Our present experiments are focused on providing conclusive arguments for a successful observation of the KK TR process in Ar ions.

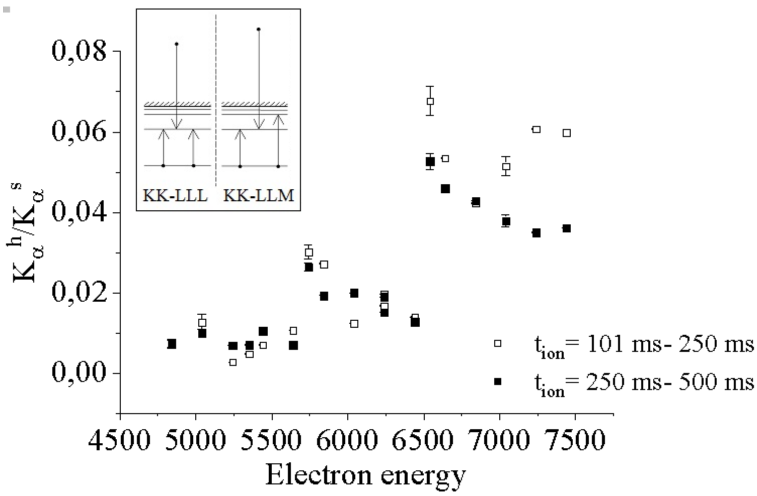

Figure 1. Ratio of Ar hypersatellite to satellite peaks scanned in the expected KK TR electron energy range. Inset shows examples of KK TR.

References

[1] G. Zschornack, M. Schmidt, A.Thorn, **CERN Yellow Report 007**, 165-201 (2013)

[2] C. Beilmann, P. H. Mokler, S. Bernitt, *et al.* **Phys. Scr. T144**, 014014 (2011)

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