Projectile K-Shell Vacancy Production in $U^{89+} \rightarrow N_2$ Collisions: Selective Population of the 2s-States in He-Like Uranium

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Until now, atomic physics experiments at the ESR storage ring focused on initially bare and hydrogen-like ions. However, there is an increasing demand to extend the range of possible structure and collision studies to heavy high-Z multi-electron systems such as helium-, lithium-, or beryllium-like ions. To accomplish the storage of intense heavy few-electron systems even at the highest beam energies possible at the ESR, thin carbon stripper foils are now available in the beam transfer line between SIS and ESR. In contrast to the commonly used copper stripper targets, carbon foils guarantee a strong yield enhancement for heavy multi-electron ions (see. Fig. 1). Very recently, this new possibility for atomic physics experiments has been exploited by injecting intense SIS beams of lithium-like uranium into the ESR at an energy of 217 MeV/u. In this experiment, projectile x-ray emission arising from collisions with a N_2 target was measured by intrinsic germanium detectors in coincidence with down-charged or up-charged ions, i.e. ions having captured (U^{88+}) or lost (U^{90+}) one-electron in the collision. For a detailed description of this set-up we refer to Ref. [1]. In the following we concentrate on the process of K-shell ionization. In Fig. 2 the x-ray spectrum observed at an forward angle of $\approx 10^o$ in coincidence with electron-loss is depicted. The spectrum is entirely governed by an intense single L→K (Kα_2) transition and a broad continuum distribution. Since we are dealing with He-like uranium produced by K-shell vacancy production of the Li-like species, the broad continuum can be explained by the two-photon decay (**2E1**) of the $[1s_{1/2}, 2s_{1/2}]^1S_0$ level. Consequently, the single Kα transition observed arises exclusively from the **M1** decay of the $[1s_{1/2}, 2s_{1/2}]^3S_1$ state. To the best of our knowledge, no other process occurring in ion-atom collisions is known with such a high state selectivity. This also means that the 2s-electron stays passive during a collision leading to K-shell ionization because no decay from the neighbouring excited p-states is observed (see level scheme inserted in Fig. 2). This unexpected and surprising finding is currently subject of theoretical studies.

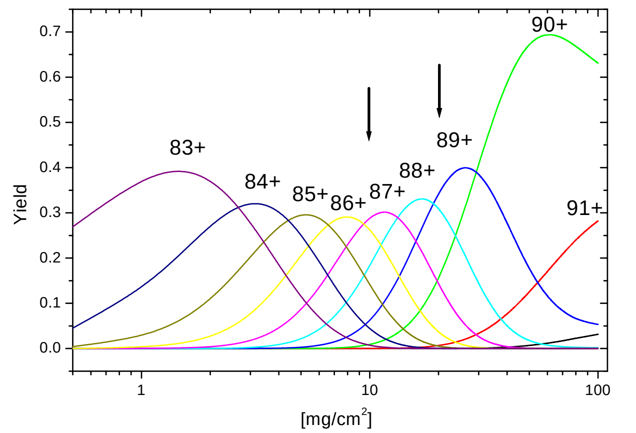

Figure 1: Calculated charge state evolution as function of target thickness for uranium ions traversing through a carbon foil at an energy of 300 MeV/u. For the calculation the program GLOBAL has been used [2]. The arrows mark the target thickness of the stripper targets installed.

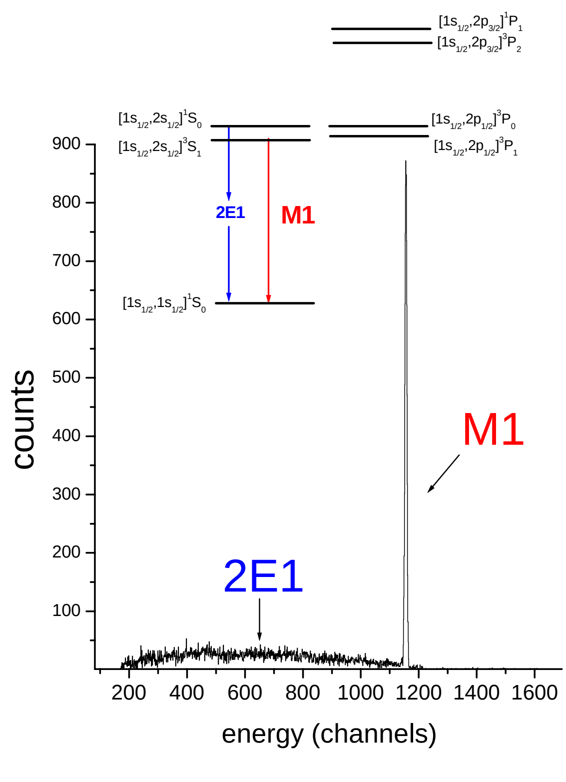

Figure 2: X-ray spectrum measured in coincidence with electron loss for $U^{89+} \rightarrow N_2$ collisions at 217 MeV/u. In the upper part, the level scheme of He-like uranium illustrates the origin of the observed photon emission.

References

[1] Th. Stöhlker et al., in:"X-Ray and Inner Shell Processes", AIP Conference Proc. 506, 389 (2000).

[2] C. Scheidenberger et al., Nuclear Instr. and Methods B **142**, 441 (1998).