Two-electron one-photon transition in Li-like Bi

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We report on experimental study of the decay properties of $1s(2s^2)$ state in Li-like bismuth (Z=83), adopting a state selective K-shell ionization technique [1]. This state is expected to undergo predominantly an exotic $1s(2s)^2 \rightarrow (1s)^2 2p_{1/2}$ two-electron one-photon decay (TEOP) [2, 3], which is interesting because of its sensitivity to electron correlation effects. In the high-Z ions the $1s(2s^2)$ state can also decay to the ground $(1s)^2 2s$ state via a radiative magnetic dipole M1-transition. The strong variation of the decay properties of the states along the isoelectronic sequence is an ideal testing ground for our understanding of the interplay of electron correlation and relativistic effects in a few-electron ions. The experiment was performed at the ESR (GSI) with 98 MeV/u Be-like bismuth ions colliding with a gas jet target (N_2). The x-rays produced in this process (see Fig. 1) were measured under an angle of 35° with respect to the propagation direction of the ion beam (for details concerning the setup see [1]). By the coincident registration of x-rays with the charge state of the ions after the collision, few different radiative processes can be separated: K-shell excitation of the Be-like ions, the radiative electron capture and the formation of excited states of the Li-like ions produced by K-shell ionization. As can be seen in the ionization spectrum (Fig 1:Ionization), K-shell ionization appears to be a very selective population process, because in the associated photon spectrum only one single x-ray line is observed stemming from the decay of the $1s(2s^2)$ state.

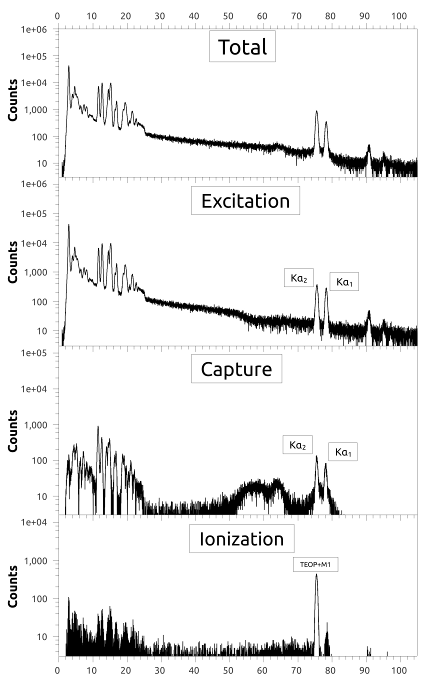

Figure 1: Preliminary x-ray spectra recorded for $Bi^{79+} \rightarrow N_2$ (see text for details).

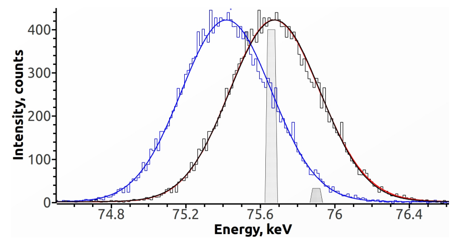

Figure 2: Preliminary analysed ionization spectrum peak; blue steps / blue line: the peak position defined by radiative sources calibration/ the corresponding fitting curve; black steps / black line: the peak position obtained by the calibration based on the theoretical Kα1 and Kα2 lines / the corresponding fitting curve; grey boxes: theoretical predictions for the TEOP (left) and M1 (right) transitions with the widths corresponding to the theoretical uncertainties; red line: convolution of the theoretical predictions [3].

The energy separation between the two transitions of interest, TEOP[$1s(2s^2) \rightarrow (1s)^2 2p_{1/2}$] and M1[$1s(2s^2) \rightarrow (1s)^2 2s_{1/2}$], is close to 250 eV in the emitter frame. Due to the lack of high resolution x-ray detectors within the current investigation, the goal of the current data analysis is to determine M1/TEOP branching ratio, i.e. the contamination of the TEOP by the M1 decay, using an accurate line centroid determination of the observed x-ray line. Apart from a conventional method utilising an accurate calibration of the detector with radioactive sources, a complementary calibration method was used based on corresponding energies of the Kα1- and Kα2-lines, produced by excitation (Fig. 1:Excitation), as an energy reference. The latter provides an important cross-check for the Doppler corrections to be applied. This, however, is based on the assumption that K-shell excitation of the Be-like ions occurs to the $1s(2s)^2p_{3/2}$ and $1s(2s)^2p_{1/2}$ levels exclusively. Preliminary results are presented in the Fig. 2, suggesting a dominance of the TEOP over the M1 transition. The data analysis is in progress.

References

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