4 - 19 Double K-shell Ionization of Kr Induced by Swift Xe^{54+} Ions

Shao Caojie, Yu Deyang, Wang Wei, Xue Yingli, Zhang Mingwu, Yang Bian,
Song Zhangyong, Lu Rongchun, Liu Junliang and Cai Xiaohong

Double K-shell ionization of atoms by collisions with charged ions is one of typical two-electron processes and attracts considerable attention both in term of basic theory and experiment. Radiative de-excitation of the double K-shell vacancy states of atoms leads to the emission of so called K X-ray hyper-satellites ($K_\alpha{}^h$,$K_\beta{}^h$ ...)[1], which gives us the insight into the decay modes of multiply ionized ions as well as the ionization processes during ion-atom collisions. Contrary to the long-winded and difficult experiments with heavy target due to the low detection efficiency of K X-ray hyper-satellites with crystal spectrometers[2−4], the bulk of knowledge concerning double K-shell ionization in ion-atom collisions has been obtained for light target.

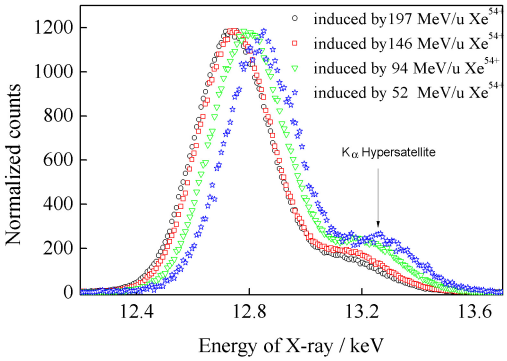

Fig. 1 (color online) K_α X-ray spectra of Kr atom induced by 52∼197 MeV/u Xe^{54+}.

In this work, we report on the double- to single-K-shell ionization ratios of Kr by collisions with 52, 94, 146, and 197 MeV/u Xe^{54+} ions. Taking advantage of the storage ring and its internal target facility where secondary effects could be negligible and charge state could keep single, the double- to single-K-shell ionization ratios for the four collisions were investigated by detecting corresponding K_α line. The measured K_α X-ray energy spectra of Kr obtained at 90° observe angle with a Si (Li) detector are presented in Fig. 1. The K_α X-ray hypersatellites were resolved by Si (Li) detector with energy resolution of 250 eV at 12.6 keV. The peaks position and counts of hypersatellites could be extracted by double-Gaussian function fitting.

Experimental values were compared with theoretical ones obtained within the independent electron model (IEM)[5] employing single electron probabilities calculated with the semi-classical approach (SCA)[6]. This comparison suggests that first order perturbation approximation is consistent well with the experimental result at 197 MeV/u projectile collision while breaks down for the lower energies.

References

[1] J. P. Briand, Phys. Rev. Lett 27(1971)777.

[2] P. Richard, W. Hodge, C. F. Moore. Phys. Rev. Lett, 29(1972)393.

[3] D. Olsen, C. F. Moore. Phys. Rev. Lett, 33(1974)194.

[4] P. Richard, D. K. Olsen, R. Kauffman, C. F. Moore. Phys. Rev. A, 7(1973)1437.

[5] R. L. Becker, A. L. Ford, J.F. Reading. Nucl. Instr. and Meth, 214 (1983)49.

[6] J. M. Hansteen. Adv. At. Mol. Phys, 11(1975)29.