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High energy resolution measurements of the radiative decay of double K-shell vacancies in $20 \leq Z \leq 29$ elements bombarded by fast C and Ne ions

J.-Cl. Dousse[*] [1], Y.-P. Maillard[*], M. Berset[*], D. Castella[*], J. Hoszowska[*], M. Kavčič[†], M.Kobal[†], O. Mauron[*], A. Muehleisen[†], P.-A. Raboud[*], J. Rzadkiewicz[‡], K. Tökési[£] and B. Zorko[†]

[*] Department of Physics, University of Fribourg, CH-1700 Fribourg, Switzerland
[†] J. Stefan Institute, SI-1001 Ljubljana, Slovenia
[‡]National Centre for Nuclear Research, 05-400 Otwock, Swierk, Poland
[£] Institute of Nuclear Research of the Academy of Sciences (ATOMKI), H-4001 Debrecen, Hungary

Synopsis. We report on high energy resolution measurements of the Kα hypersatellite x-ray spectra of Ca, V, Fe and Cu induced by impact with 144 MeV C and 180 MeV Ne ions.

The double inner-shell ionization induced by photon and electron impact is rather weak. In contrast to that, x-ray satellites and hypersatellites with markedly higher intensities are observed in x-ray spectra resulting from collisions of atoms with heavy ions. Due to the strong Coulomb field of the projectile, several inner-shell electrons of the target atom can be indeed ionized simultaneously. As a consequence, x-ray spectra induced by heavy ion impact exhibit usually rich satellite and hypersatellite structures. High-resolution measurements of heavy-ion induced *K*-hypersatellites were found to be a sensitive tool for investigating the relativistic and quantum electrodynamics (QED) effects in atoms [1] and the dynamics of multiple ionization of atoms by heavy-ion impact [2].

In the present experiment the K-shell double ionization of Ca, V, Fe and Cu induced by impact with 12 MeV/amu C^{4+} ions and 9 MeV/amu Ne^{6+} ions was investigated. The measurements were performed at the Paul Scherrer Institute (PSI) in Villigen, Switzerland. The ions produced by a 10-GHz CAPRICE ECR source were accelerated to the final energies by the variable energy Philips cyclotron of PSI. The x-ray spectra were measured by means of high resolution x-ray spectroscopy, using the von Hamos curved crystal spectrometer of Fribourg [3]. The intensity of the beam which was in the range of 100–200 nA was monitored by observing the sample K x-ray fluorescence by means of a Si PIN photodiode. The fluorescence x-rays from the target were collimated by a 0.2 mm tantalum slit defining the effective source width. The Ca and V spectra were collected using a LiF (200) crystal, whereas for Fe and Cu a SiO_2 (2-23) crystal was employed. The diffracted x-rays were measured with a two-dimensional position-sensitive deep depleted CCD detector.

For illustration, the x-ray spectrum corresponding to the Ne-V collision is depicted in figure 1. As shown, L-satellites up to the 4th order were observed for the diagram and hypersatellite transitions.

From the fits of the high-resolution x-ray spectra, the centroid energies, linewidths and relative intensities of the transitions of interest were extracted and compared to theoretical predictions. A particular aim of this project was to determine the double K-shell photoionization cross sections for the investigated collisions. The cross sections were derived from the hypersatellite-to-diagram intensity ratios and compared to theoretical calculations performed within the SCA and CTMC models.

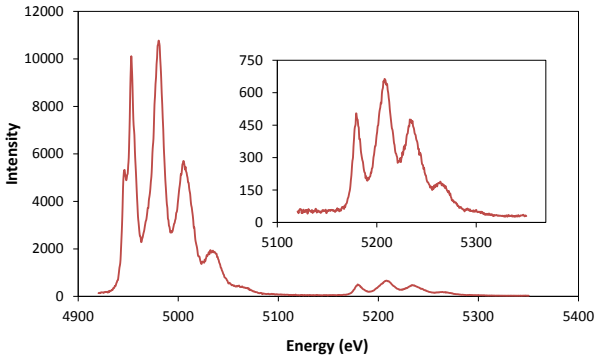

Figure 1. High-resolution K x-ray spectrum of V induced by impact with 180 MeV Ne ions. The first group of lines correspond to the $K\alpha L^n$ diagram and L-satellite transitions, the second one to the $K\alpha^h L^n$ hypersatellite transitions.

References

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[1]E-mail: jean-claude.dousse@unifr.ch