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The satellites and hypersatellites of $L\alpha_{1,2}$ and $L\beta_1$ x-ray transitions in zirconium excited by oxygen and neon ions

M. Czarnota*, [1], M. Pajek*, D. Banaś*, J.-Cl. Dousse†, M. Berset†, O. Mauron†, Y.-P. Maillard†, P. A. Raboud†, J. Hoszowska†, M. Polasik⋆, K. Słabkowska⋆, D. Chmielewska°, J. Rzadkiewicz°, Z. Sujkowski°

*Institute of Physics, Jan Kochanowski University, 25-406 Kielce, Poland
†Department of Physics, University of Fribourg, CH-1700 Fribourg, Switzerland
⋆Faculty of Chemistry, Nicholas Copernicus University, 87-100 Toruń, Poland
°Sołtan Institute for Nuclear Studies, 05-400 Otwock-Świerk, Poland

Synopsis The interpretation of L-shell satellites and hypersatellites for $L\alpha_{1,2}$ ($L_3 \rightarrow M_{4,5}$) and $L\beta_1$ ($L_2 \rightarrow M_4$) x-ray transitions in zirconium multiply ionized by oxygen and neon ions is reported. The x-ray spectra were measured with a high-resolution von Hamos spectrometer and interpreted in terms the relativistic multi-configuration Dirac-Fock (MCDF) calculations. The ionization probabilities of L- and M-shell derived from the data are compared with the predictions of the semiclassical approximation (SCA) calculations.

The high-resolution measurements of $L\alpha_{1,2}$ and $L\beta_1$ x-ray satellites and hypersatellites emitted from multiply ionized zirconium give access to study the fine details of a structure of multi-vacancy states in these atoms. Such measurements are important for testing the atomic structure calculations, in particular, the relativistic multi-configuration Dirac-Fock (MCDF) approach, including the Breit and QED corrections.

The high-resolution measurements of Zr $L\alpha_{1,2}$ and $L\beta_1$ x-rays excited by oxygen and neon ions were performed at the Philips cyclotron in the Paul Scherrer Institute (PSI) in Villigen, Switzerland, using O^{6+} and Ne^{6+} ions with energy 278.6 MeV and 177.9 MeV respectively. The excited L-x-rays were measured with a high-resolution diffraction von Hamos spectrometer [1] having an instrumental energy resolution of 0.3 eV for studied x-rays, which was absolutly energy calibrated to about 0.3 eV [2]. The measured high-resolution spectrum of Zr $L\alpha_{1,2}$ x-ray satellites and hypersatellites and $L\beta_1$ satellites excited by neon ions is shown in the figure. In order to interpret the observed satellites and hypersatellites structures the relativistic MCDF calculations [3] were performed for multi-vacancy configurations expected to be excited in collisions with O and Ne ions.

To our knowledge, this is the first experimental observation of a direct excitation of the L-shell hypersatellites in ion-atom collisions, which is, additionally, clearly interpreted by a complex MCDF calculations performed revealing their internal structure corresponding to the multi-vacancy ($L^{-2}N^{-n}M^{-m}$) configurations.

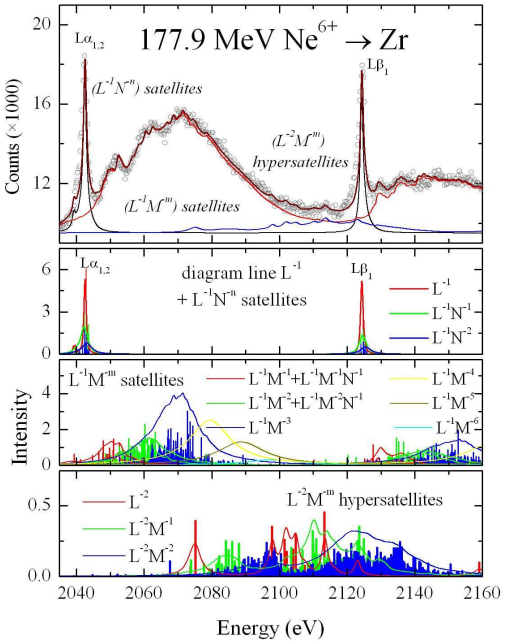

Fig. 1. Measured x-ray spectrum of Zr $L\alpha_{1,2}$ and $L\beta_1$ transitions excited by neon ions. The data are compared with the MCDF calculations for M- and N-shell satellites and L-shell hypersatellites.

References

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[1] E-mail: marcin@ujk.kielce.pl