Shake transitions in photoionization of sodium excited by two lasers

M. Meyer*[1], D. Cubaynes†, E. Heinecke‡, P. Zimmermann‡, O.I. Zatsarinny§, E.V. Gryzlova¶, A.N. Grum-Grzhimailo¶[2]

* European XFEL, Albert-Einstein-Ring 19, 22761 Hamburg, Germany
† Institut des Sciences Moléculaires d'Orsay, Centre Universitaire Paris-Sud, F-91405 Orsay Cedex, France
‡ Institut für Optik und Atomare Physik, TU Berlin, Hardenbergstrasse 36, D-10623 Berlin, Germany
§ Department of Physics and Astronomy, Drake University, Des Moines, Iowa 50311, USA
¶ Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow 119991, Russia

Shake phenomena are a clear manifestation of electron correlations and are found in numerous atomic processes. They give rise to rich satellite structures, which are studied e.g. in photoionization, radiative and Auger decay, scattering of charged particles, nuclear beta decay, etc. For shake transitions in photoionization from inner shells of highly excited atoms, the mechanisms and the range of validity of different theoretical models [1, 2, 3] still require clarification. Meaningful conclusions can be formulated only in comparision with high-quality experimental data.

Photoionization of the subvalence 2p shell in atomic sodium often serves as example to study the shake satellites in the photoelectron spectra, because of the comparatively simple atomic structure and the possibility to control the state of the valence electron by means of the laser optical pumping [4]. In the present contribution we investigate both experimentally and theoretically the shake transitions in the photoionization from the Na 2p shell upon excitation of the outer electron into $4d_{5/2}$ and $5s_{1/2}$ orbitals, respectively.

The experiments were performed at the synchrotron radiation source BESSY II using angle-resolved high-resolution electron spectroscopy. Ground-state sodium atoms were excited stepwise by two c.w. ring-dye lasers, first to the $3p_{3/2}$ and subsequently either to the $5s_{1/2}$ or the $4d_{5/2}$ state. As an example, Fig. 1a shows the experimental spectrum recorded upon excitation to $4d_{5/2}$, after subtracting the contributions caused by ionization from the $3s_{1/2}$ ground and $3p_{3/2}$ excited state. Dominating transitions of the Rydberg electron contributing to the spectrum are indicated. Numerous satellites are observed as a result of shake processes. As a rule, one line in the spectrum contains a few experimentally unresolved transitions between the fine-structure levels. Detailed calculations are therefore needed to describe the observed spectra. Theoretical models used in the present analysis are the B-spline R-matrix method (BSR) [5] and two versions of the sudden perturbation approximation. Fig. 1b presents the 138-state BSR calculations, convoluted with the experimental resolution of 40 meV, and taking into account the relative populations $W(nl_j)$ of the states $4d_{5/2}$ as well as $4p_{3/2}$ and $4s_{1/2}$, populated by radiative cascades.

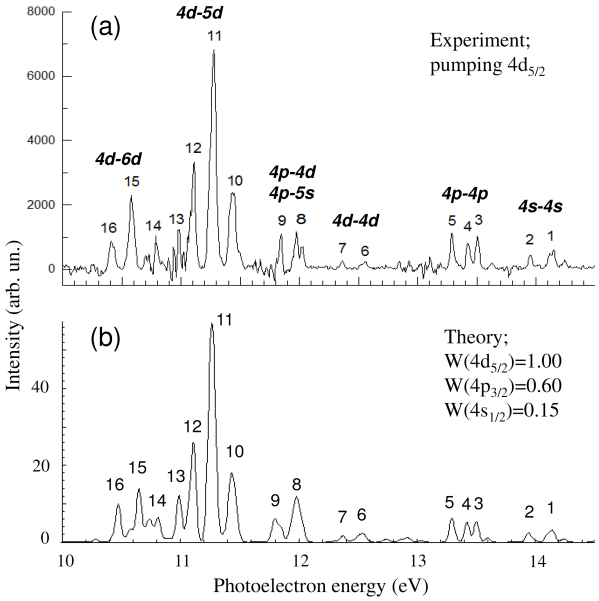

Figure 1. Measured (a) and calculated (b) electron spectrum at $h\nu = 57$ eV (see text).

More detailed discussions of our results will be presented at the conference.

References

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[1] E-mail: michael.meyer@xfel.eu
[2] E-mail: algrgr1492@yahoo.com