ESRF

Experiment title:
Spin-resolved photo- and Auger-electron spectroscopy on free atoms and molecules using circularly-polarized soft x-ray radiation

Experiment number:
M1-120

Beamline:
ID 12 BL 26

Date of Experiment:
from: 13 Feb. 1996 to: 28 Feb. 1995

Date of Report:
29.8.96

Shifts:
30

Local contact(s):
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Received at ESRF :

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Report:

Photoionization of atoms and molecules by circularly polarized radiation is accompanied by transfer of angular momentum from the photon to the photofragments. After successful studies of photo- and Auger electrons by means of spin-resolved electron spectroscopy **[1]** during our last beamtime we additionally investigated more subtle atomic behaviour such as the emission of satellite lines in the photoelectron spectrum. These measurements are the first of their kind.

The emission of atomic photoelectrons is often accompanied by the simultaneous emission of satellite lines. Satellite emission is a showcase example of electron correlations since the ionization of an atomic shell is accompanied by the excitation of an other electron. The necessary energy for such an excitation reduces the photoelectron energy and the satellite lines appear at lower kinetic energies. Due to the manifold possibilities of excitation and the different mechanisms (e.g. Initial and Final State Configuration Interaction) a rich line structure of satellites arises. This means that, for a successful measurement both a high resolution monochromator and a high resolution electron spectrometer are required. Furthermore, for a detailed study a higher degree of differentiation in the experimental method is needed (such as angle- and spin-resolved spectroscopy) since the overlapping lines in many cases cannot be separated energetically.

Since our targets are in the gas-phase a windowless 3 stage differential pumping system was used for vacuum separation between the experimental chamber and the beamline. The detector system consisted of a time-of-flight (TOF) electron energy analyzer combined with a spherical, retarding field Mott-detector. The utilisation of a TOF electron spectrometer made the

16-bunch operation mode of the **storage ring** necessary. The argon satellite spectra were obtained at a photon energy of 543.0 eV with a resolving power of ~1300. By applying a retarding potential U_{ret} = - 230 V to the spectrometer drift tube an energy resolution of $\Delta E / E \sim 10^{-3}$ was achieved. Together with the high resolution a high flux had to be maintained due to the losses in the spin-detector.

Argon is easier to handle theoretically than our previous target Xe, since the LS-coupling scheme can be applied and relativistic effects can be neglected. On the other hand he photoionization cross sections in the soil x-ray energy region are a factor 2-4 lower than those of Xe (Ar ionization thresholds at $250.6\,eV$ for $2p_{1/2}$ and $248.4\,eV$ for $2p_{3/2}$).

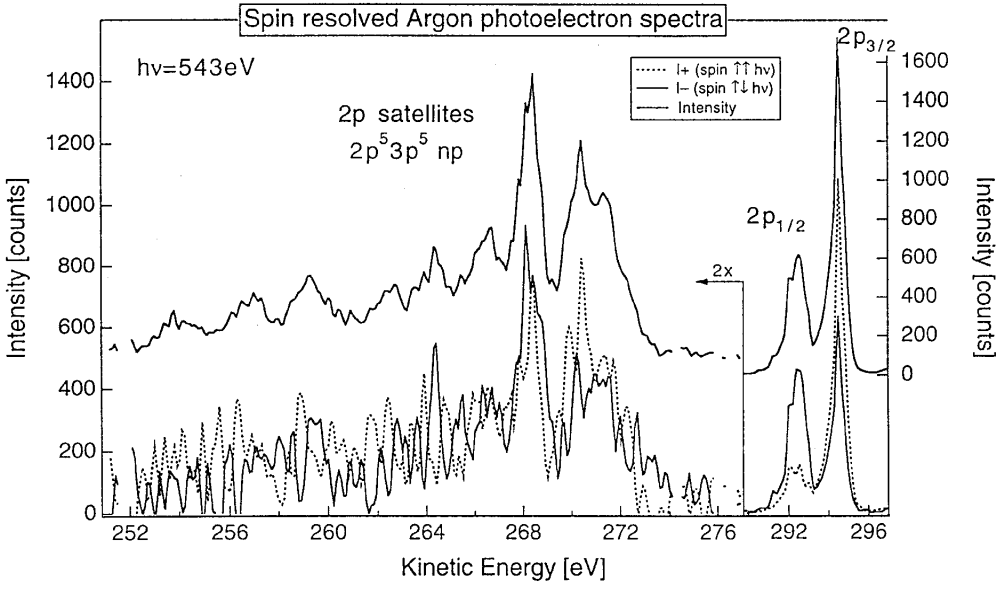

Figure: Electron spectra of the Argon 2p photolines and the corresponding satellites. Top: “normal” high resolution spectrum; Bottom: spin-resolved spectra.

The fig. shows the 2p satellite spectra of Argon. The top curve is a high resolution electron intensity spectrum obtained with a TOF spectrometer. At the bottom the spectrum is separated into two components according to electrons spin-polarized parallely and antiparallel to the direction of the photon beam. The opposite polarization of the two 2p fine-structure components is obvious. The satellites are clearly splitted into a 1/2 and, a 3/2 component revealing a very detailed structure. Especially for the two prominent satellite lines the composition of the non-spin resolved spectrum from the two oppositely polarized spin components is demonstrated.

Also the Ar LMM Auger electrons, measured at 543 eV, were found to exhibit a pronounced effect in the spin polarization transfer.

In order to interpret spin polarization data quantitatively knowledge of the degree of circular polarization P_{circ} of the incoming radiation is needed. Our previous measurements of P_{circ} of the helical undulator HELIOS I were extended down to 520 eV using a multilayer reflection analyzer. At 543 eV we found P_{circ} = 0.74 ± 0.03 and P_{tot} = 0.95 ± 0.05 [2].

[1] G. Snell, M. Drescher, N. Muller, U. Heinzmann, U. Hergenhahn, J. Viefhaus, F. Heiser,U. Becker, and N. B. Brookes, Phys. Rev. Lett. 76,3423 (1996)

[2] M. Drescher, G. Snell, U. Kleineberg, H.-J. Stock, N. Muller, N. B. Brookes and U. Heinzmann, submitted to Rev. Sci. Instr.