ESRF	**Experiment title:** Spin-resolved electron spectroscopy on rare earth metals using circularly-polarized soft x-ray radiation	**Experiment number:** HE-35
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Report:

The aim of our experiment is to study the angular momentum coupling of the two-particle states involved in the decay processes of excited core-hole states in 3d-transition metals and in the rare-earth metals inter alia. To this purpose the spin-spin correlation between oriented hole states excited by circularly polarized radiation and electrons emitted by autoionization and Auger-decay processes is probed.

In our apparatus the circularly polarised radiation passes the 90" spherical electron spectrometer and hits the target at normal incidence. Electrons emitted inside a cone of about ±1° around the surface normal are decelerated, energy analysed by the spectrometer and imaged into the retarding spherical Mott-polarimeter for spin polarization analysis.

Bearing in mind the problems with the spectrometer power supplies during our beamtime in April 1996, we firstly investigated the L_3VV Auger process in Cu. For exciting the L_3 hole-states we used radiation with energy of 937eV ± 4.5eV (insert in Fig.1). The spin resolved data are displayed in Fig. 1 by partial intensities I+ and I_ representing electrons totally spin polarized parallel and antiparallel to the photon spin, respectively. Each, I+ and I_, are background-corrected using ref 1. The vertical bars taken from ref. 2 represent positions and intensities of the predominant (atomic) multiplet states $^1S_0$, $^1G_4$ and $^3F_{2,3}$ of the two-hole configurations left behind in the 3d-states. The results are:

- the $^1G_4$ peak and the $^1S_0$ peak are preferentially built up by I+, i.e. by electrons with spin parallel to the photon spin,
- the preferred spin orientation is inverted for the $^3F_{2,3}$ peak,
- the preferred spin orientation found here in the $^1G_4$ line is contrary to the one we found with the M_3VV Auger process [3] using Cu(100) instead of Cu(l11).

On the basis of our present data we cannot decide whether the preferred spin orientation found to be different here is due to the changed crystal orientation or due to p → d primary excitations possible near to E_F [4]. Due to the energy width of 9eV we expect primary excitations from 2p-states to 4s-derived states to dominate in our present experiment. It is worth noting that the preferred spin orientation found in the L_3VV Auger peak at CuO after 2p → 3d excitation by circularly polarized radiation [5] is identical to the one revealed here. All in all, our results agree with the atomic model of the L_3VV Auger process in Cu. Especially at the low energy side of the $^1G_4$ line no significant line shape differences for I_+ and I_ are present, which contradicts our results for the M_3VV process on Cu(lO0) [3].

With the measurements on Cu(111) the counting rate was sufficiently high (approx. 50 cps at peak maximum, spectrometer resolution $\Delta E < 1eV$). With the Gd films grown onto W(110) at the 3d → 4f resonance the intensity was found to lie just at the lower limit acceptable for measurements (10 cps at peak maximum, channelplate background 4 cps, pass energy 140eV resulting in AE = 1.4ev). Studying emission processes out of the 3d → 4f resonance has proven not to be practicable without enlarging the angular acceptance of our spectrometer and improving the Mott-polarimeter.

Our results measured at the Gd 3d → 4f resonance using the photon energy 1184.4eV ± 1.3eV is presented in Fig. 2. The emitted electrons show a preferred spin orientation parallel to the photon spin. This is identical to that which (due to the relativistic dipole selection rules) the electrons resonantly excited from 3d to 4f states should have. Therefore the emission process is clearly identified to be an autoionization process [6] and the electrons filling up the Jd-holes should have a preferred spin orientation antiparallel to the one of the resonantly excited electrons. The important role of spin-orbit coupling inside the core states is evident.

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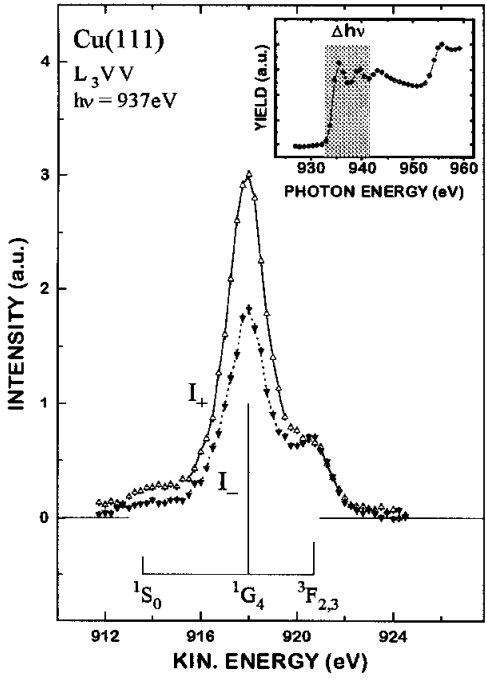

Fig. 1: Spin resolved L_3VV Auger spectrum measured at Cu(lll). For I_+ and I_- see text. Position and size of the bars representing the dominant multiplets are taken from Ref 2. The error bars give the statistical error only. There is an additional error due to the calibration uncertainty of the Mott-polarimeter. The insert shows a total yield spectrum from Cu(ll1) and the energy width of the exciting radiation.

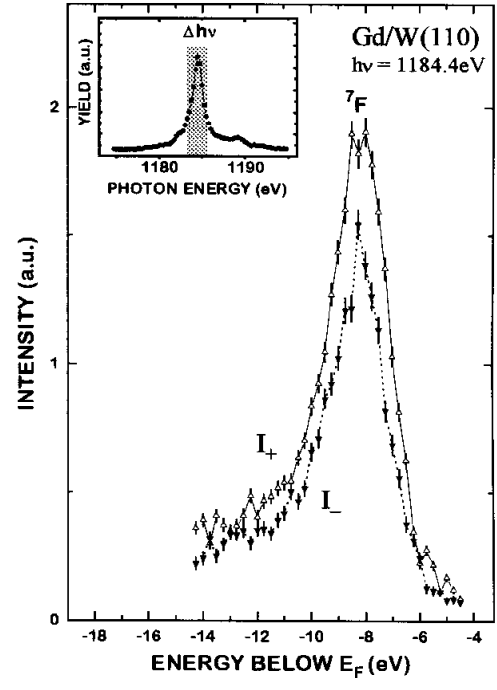

Fig. 2: Spin resolved electron emission spectrum measured at Gd/W(llO) at the 3d → 4f resonance. For I_+ and I_- see text. For the error bars see Fig. 1. The insert shows a total yield spectrum from Gd/W(llO) and the energy width of the exciting radiation.