Angle resolved resonant photoemission in transition metals

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The resonant photoemission (PE) phenomenon is understood as an interference between two different channels leading to the same final state. The two channels considered are the direct PE and the dipole transition of a core electron to a discrete unoccupied state, ocurring at energies close to a particular absorption threshold, the result is a strong variation of the PE cross section[1,2]. Since the probability for resonant PE depends critically on the strength of configuration interaction and, therefore on the localization of the core-excited state, the question arises whether the signal observed in resonant PE reflects exclusively this excitation process or is due in part to a secondary process of the excited state. Only in the first case can the spectral features be interpreted as resonant PE, in the second case an incoherent superposition of PE and Auger signals occurs. In a previous work[3] it was shown that the photoelectron spectra of Ni, Fe and Co metal at the L_{III} thresholds have to be described by an incoherent superposition of an intense $L_3M_{4,5}M_{4,5}$ Coster-Kronig Auger with a relatively weak PE signal. This finding deviates dramatically from the established picture of resonant PE phenomena and was explained as a loss of coherence between the two channels caused by the itinerant character of the intermediate state, $2p^53d^{n+1}$. Therefore it was necessary to test whether an analogous mechanism caused the established *resonant PE* of the 6 eV valence-band satellite at the M_{III} threshold in the photoelectron spectrum of Ni metal. This question can be addressed by measuring the intensity of the various spectral components as a function of the electron emission angle relative to the **E**-vector of the incident light. In the case of a PE process, the intensity should show a cos^2 behaviour, while an Auger signal ought to be isotropic in the case of a pollycrystalline sample. On the basis of these arguments, a distinction between PE and Auger contribution should be possible by means of angle-dependent electron-spectroscopy measurements. This kind of experiment was performed for the case of Ni metal[4] showing that the resonant enhancement of the 6 eV satellite was almost completely due to an incoherent superposition of an Auger and a PE signal.

In this work, we present the results of an study of resonant photoemission at the M_{III} threshold of Fe and Co metal ($3p\rightarrow3d$ resonance). The intensity of the various spectral components was measured as a function of the electron emission angle relative to the **E**- vector of the incident light. Though the intensity of the valence-band PE signal varies roughly according to a cos^2 law, the intensity of the enhanced feature at $\approx$ 6 eV is found to be independent of the emission angle, as expected for an incoherent Auger process. This result agree with the previous work on Ni metal.

The measurements were performed at the TGM-5 beamline of the Berliner Elektronenspeicherring für Synchrotronstrahlung (BESSY) using a VSW-ARIES angle-

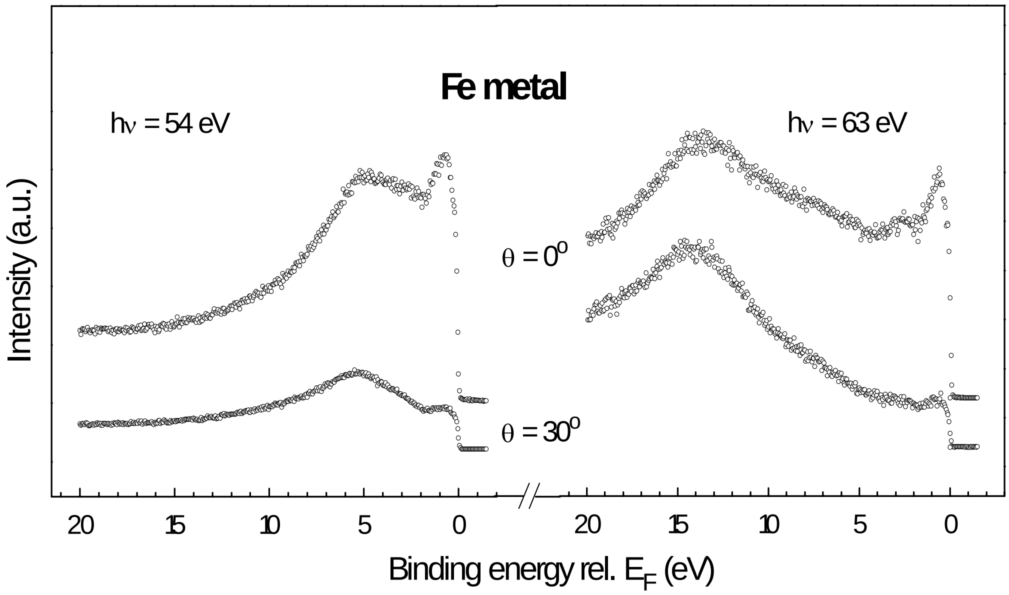

Figure 1: Valence-band photoemission spectra of Fe metal on (hν=54 eV) and off (hν=63 eV) resonance for three values of ϑ (see text).

resolved electron spectrometer. Polycrystalline samples were used to avoid angular dispersion effects. The surfaces of the samples were cleaned by scraping with a diamond file.

Fig.1 shows the valence-band PE spectra of Fe metal on (hν=54 eV) and off (hν=63 eV) resonance for two different values of ϑ, where ϑ is the angle between the electron emission direction and the **E**-vector of the incident light. The spectra were normalized to equal intensities of the off-resonance Auger signal. This is justified on the basis of an isotropic Auger emission for a pollycrystalline sample. This normalization process leads to an intensity angular variation of the on-resonance 6-eV feature approximately constant, and for the main valence-band peak (1 eV binding energy) a cos^2 behaviour. This means that the 6 eV peak behaves like an Auger signal and cannot be described as resonant PE.

Fig. 2 shows the valence-band spectra of Co metal, taken on (hν=60 eV) and off (hν=68 eV) resonance for three different values of ϑ. After the same normalization procedure as in the previous case, we can also see that the behaviour is quite similar. The intensity of the 6-eV feature of the on-resonance spectra is almost constant with the angle variations. However, the main peak follows the cos^2 behaviour. Therefore we can assign the enhanced 6-eV feature to an Auger signal and not to a resonant PE process.

In conclusion, we have shown that the resonant enhancement of the 6-eV feature in the on-resonance spectra of the valence-band signal on Fe and Co metal is mainly due to an Auger emission. This result agree with a previous angular dependence work performed on Ni metal[4], and also with a resonant PE study on the L_{III} threshold on Fe and Co metal[3]. The reason of this phenomenon is the lack of the coherence between the two channels necessary for the ocurrence of the resonant PE process. This loss of coherence is due to the itinerant character of the 3d states in the transition metals.

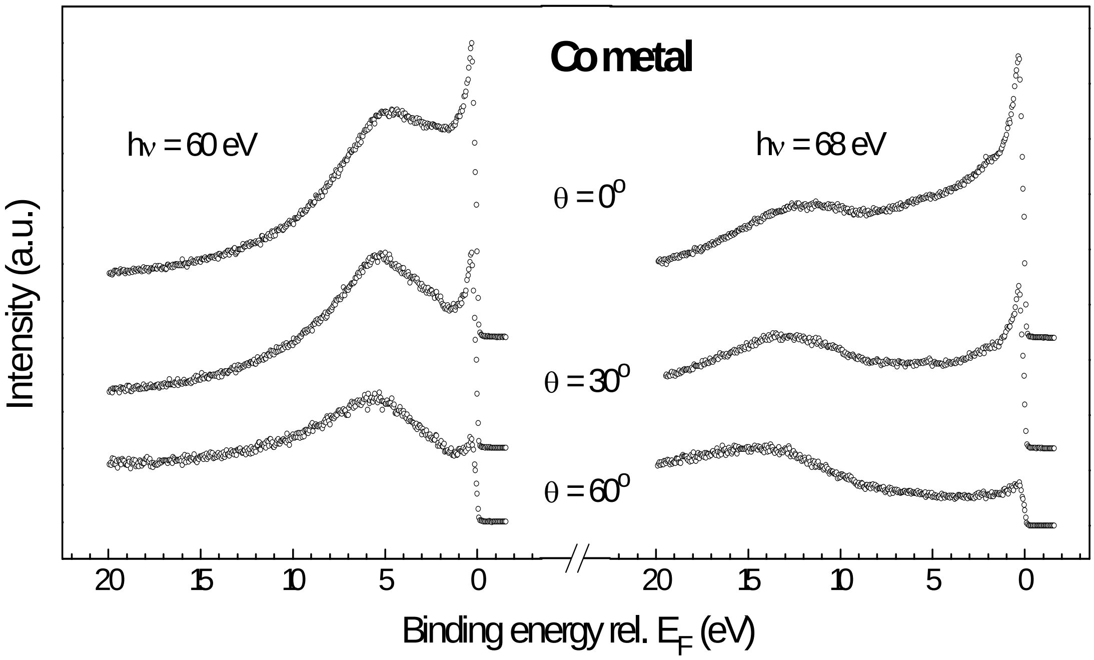

Figure 2: Valence-band photoemission spectra of Co metal on (hν=60 eV) and off (hν=68 eV) resonance for three values of ϑ (see text).

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