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Photoemission from UTe$_x$Sb$_{1-x}$

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Résumé. — Les spectres de photoémission des monocristaux de UTe, UTe$_{0.12}$Sb$_{0.88}$ et USB dans le domaine d'énergie de photons allant jusqu'à 11 eV ont été mesurés et interprétés en termes de densité d'états des bandes 6d et 5p. Le fait que les électrons 5f ne contribuent pas à nos spectres de photoémission est établi par l'observation d'une polarisation de spin négative dans UTe ferromagnétique.

Abstract. — Photoemission energy distribution curves obtained from single crystals of UTe, UTe$_{0.12}$Sb$_{0.88}$ and USB in the photon energy range of $h\nu < 11$ eV are interpreted in terms of the densities of states of the 6d and 5p bands. The fact that the 5f electrons do not contribute to our photoemission spectra is established by observing negative electron spin polarization from ferromagnetic UTe.

1. Introduction. — The magnetic properties of the actinides and their compounds are mainly determined by 5f electrons. Depending on their nature, new model substances intermediate between the band-like 3d transition metal ferromagnets and the localized 4f rare earth (RE) ferromagnets are provided by cubic uranium compounds.

For pure actinides, a hybridization of 6d and 5f electrons has been discussed [1] and first spectroscopic results on US [2] are interpreted in terms of this picture. Therefore, the role of the 6d electrons in magnetism and in conduction has to be clarified.

2. Experiment. — Electron energy distribution curves (EDC's) of photoemitted electrons were measured in a vacuum of $3 \times 10^{-6}$ torr on in situ cleaved (100) surfaces of UTe$_x$Sb$_{1-x}$ ($x = 0.0, 0.12, 1.0$) at 300 K. All samples crystallize in the NaCl structure and are easily cleaved along (100) planes. Angle integrated EDC's were obtained by a spherical single grid retarding field analyser and standard ac modulation technique with a resolution of 0.1 eV.

3. Results. — The photothreshold as determined from Fowler plots is $4.05 \pm 0.07$ eV for USB, $4.05 \pm 0.1$ eV for UTe$_{0.12}$Sb$_{0.88}$ and $3.94 \pm 0.05$ eV for UTe. Figure 1 shows a series of EDC's for photon energies from 5 to 10 eV obtained from UTe. The origin was chosen at the Fermi level $E_F$, determined by the high energy drop of the emission current. We note a 1.5 eV broad peak just below $E_F$, coinciding with the hybridized $f-d$ conduction band observed for US and UN [2, 3]. In going successively to higher photon energies, a second peak develops below the conduction band, which we attribute to Te derived s and p electrons.

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Recently, we have shown that the electrons in the conduction band peak have a negative spin polarization [4] (their magnetic moments antiparallel to the magnetization). Hence, they cannot be of $f$ character, as the $f$ electrons carry the major magnetization [5]. Their absence from the spectrum is attributed to very low matrix elements, as in case of US [2]. Thus our optical density of states (cf. Fig. 2) shows a conduction band, which has mostly d character, the d electrons having their magnetic moments coupled antiparallel to those of the 5f's.
Optical densities of states obtained from EDC's at $h\nu = 10.3$ eV for all three different U salts are shown in figure 2. In going from UTe to USB, we notice a 1 eV shift of the second peak towards higher kinetic energies and a narrowing by the same amount. This shift is also found for the valence band of divalent and trivalent RE compounds [6]. The conduction band peak is not so much affected, indicating that the d emission is almost unchanged. According to the negative spin polarization 5f's are absent in this peak. Hence, a 5f electron must at least partly participate in the bonding.

4. Conclusion. — In the uranium salts analysed here, the 5f electrons can participate in the chemical bonding, as deduced by comparison of EDC's of U compounds with anions of different valencies. This implies that the f electrons are more bandlike than the 4f's in RE's and 5f's in the heavier actinides.

References