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Report: Abstract - presented at 30^{iemes} Journees des Actinides, 4.-6. May 2000, Dresden, Germany.

The 5*f*-band metamagnet UCoAl crystallizes in the hexagonal ZrNiAl-type structure and is strongly anisotropic. This compound has nonmagnetic ground state, however, below 17 K the magnetic fields as low as 0.65 T oriented along the *c*-axis induce the ferromagnetic moment of 0.3 μ_B/U [1]. Above the metamagnetic transition UCoAl exhibits large high-field susceptibility and reported results of polarized neutron diffraction indicate possible field dependent orbital moment of U atoms [2].

Here we report on the X-ray magnetic dichroism (XMCD) study of UCoAl performed both in para-magnetic and ferromagnetic state. The XMCD spectra were measured trough the M_4 and M_5 edges, which correspond to the electronic transitions from the core $3d_{3/2}$ and $3d_{5/2}$ states, respectively, to the band 5*f* states. Using this technique it is possible to obtain values of the orbital (and under some conditions also spin) moment of a probed atom using the sum rules [3]. Since the sum rules involve only the integrated intensity of the absorption and dichroic spectra, the results are independent of the detailed XMCD shape. The measurements were carried out on the beamline ID12A at ESRF in Grenoble. The XMCD signal was obtained from the X-ray absorption near-edge structure recorded consecutively by reversing both the helicity of the incident beam and the polarity of the magnetic field. In this way we could eliminate the dichroism introduced by the reflections of the beam in the apparatus and the magnetic linear dichroism in sample. The spectra were measured by monitoring the total fluorescence signal. In order to extract the absorption from the fluorescence, the signal was corrected for reabsorption by comparing with the spectra of the total electron yield measured on the same beamline. The XMCD was corrected also for the degree of polarization of the incident beam.

The measurements were done on the high quality single crystal [1] on mechanically polished surface at T = 10 K. The external magnetic field varied between 0 and 7 T. The incident beam and magnetic field were both oriented along the easy *c*-axis. In Fig. 1 the absorption and corresponding dichroism spectra are presented. It

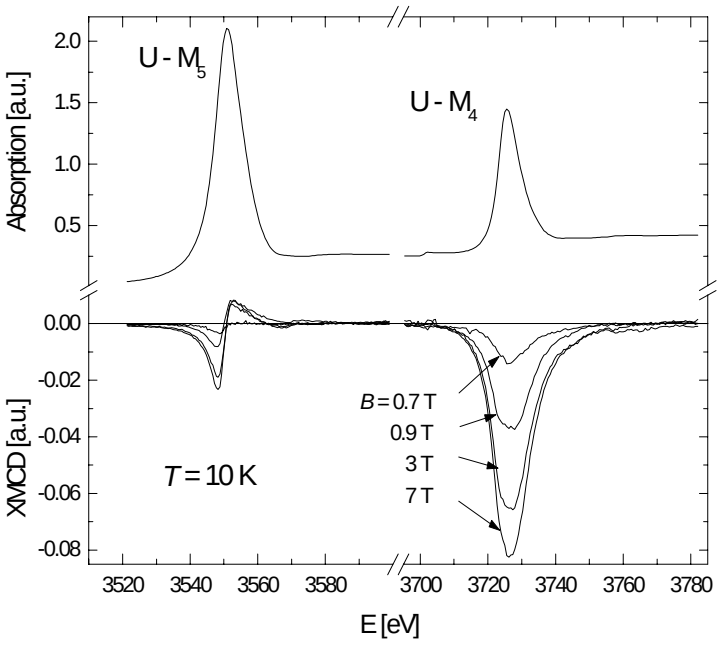

Fig. 1. Uranium $M_{4,5}$ absorption and XMCD spectra of UCoAl single crystal measured along the *c*-axis at different fields.

Table 1. Magnetic moments derived from the XMCD spectra using the sum rules. The numbers in parentheses are experimental uncertainties.

B	7 T	3 T	0.9 T	0.7 T
m_L [μ_B]	0.50 (3)	0.43 (2)	0.23 (1)	0.092 (8)
m_L/m_S	-2.7 (5)	-2.7 (5)	-2.5 (5)	-2.9 (6)

is worth noting that the differences in absorption for opposite helicities or fields are very small and these curves almost coincide and cannot be distinguished in the plot. The spectra taken at 3 and 7 T correspond to the ferromagnetic state, while that of 0.7 T - to the paramagnetic state. At 0.9 T the ferromagnetic ordering only starts to develop.

The dichroism at M_4 edge consists of a single negative lobe without any apparent structure. Such a lobe is characteristic for uranium intermetallics. The shape of M_5 edge is more complicated. At higher magnetic fields $B \geq 0.9$ T two lobes are observed, both negative and positive. However, only one negative lobe is detected at 0.7T (paramagnetic region) while the positive one does not develop at all. Especialy, the M_5 spectrum is known to be sensitive to subtle changes in electronic structure [4], and therefore hybridization effects, crystal field or exchange interaction can result in change of M_5 dichroic shape. Since the XMCD reflects the structure in the density of states above the Fermi level a splitting in DOS appearing during metamagnetic transition may be the reason for the double lobe structure of the M_5 line above the metamagnetic transition. The band structure calculations may bring more light in the speculations about the mechanism responsible for the M_5 splitting.

Application of the sum rules [3] to the spectra in Fig. 1 allows us to extract the orbital m_L and effective spin components. However, knowledge of the dipolar term is necessary in order to calculate the spin moment m_S. Since its value is not known in UCoAl the spin moment can only be estimated with relatively large uncertainty. We have adopted theoretical value of the dipolar term from ref. [5] taking for number of *5f* holes an average between the $5f^2$ and $5f^3$ configurations. The results are listed in Table 1. The calculated values are in surprisingly good agreement with those deduced from neutron experiments [2]. Likewise the total uranium moment adopts reasonable values. The results confirmed that magnetism is dominated by the orbital component, which is larger and antiparallel to the spin moment. In spite of the large relative error in the spin moment it is evident, that both orbital and spin components develop in a similar way with field. Besides, estimated ratio $|m_L/m_S|$ is rather high and is at least 2.2 for presumed $5f^3$ configuration (for $5f^2$ it would be even over 3). It is quite unusual that in a 5*f*-band magnet like UCoAl there is still preserved such a high value of the orbital moment.

References:

[1] N.V.Mushnikov et al., Phys.Rev. B 10 (1999) 6877.
[2] M.Wulff et al. Physica B 163 (1990) 331.
[3] P.Carra et al., Phys.Rev.Lett. 70 (1993) 694.
[4] P.Dalmas de Réotier et al., Phys.Rev.B 60 (1999) 10606.
[5] G.van der Laan and B.T.Thole, Phys.Rev. B 53 (1996) 14458.