ESRF	**Experiment title:** X-RAY MAGNETIC CIRCULAR DICHROISM IN [CeH_x/Fe]xn MULTILAYERS	**Experiment number:** HE-153
Beamline: ID24	**Date of experiment:** from: 07. 04. 1997 to: 16. 04. 1997	**Date of report:** 26.08.1997
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Report:

The 4f-electron states of the rare-earth element cerium are at the borderline between localization and itinerancy. Both cases can be realized, depending on the degree of hybridization of the 4f and conduction-electron states, either in the γ- or o-phase of the pure metal or in compounds with transition metals. Dramatic differences in the physical properties mirror the unlike electronic configurations. Investigations on Ce/Fe multilayers by x-ray absorption spectroscopy (XAS) and x-ray magnetic circular dichroism (XMCD) have shown that considerable 3d-5d and 3d-4f hybridization is effective at the interfaces which induces an a-phase-like electronic structure of Ce with an ordered magnetic moment on the 5d and 4f states in the ground state [1].

The experiments carried out on beamline ID24 *were* devoted to XAS and XMCD of the $L_{2,3}(2p \rightarrow 5d)$ edges of Ce in the hydrided multilayer system [CeH_2/Fe]×n which shows very unique and complex magnetic properties as, for example, a strong perpendicular magnetic anisotropy at low temperatures [2] and magnetic coupling of the Fe layers across the CeH_2 layers in longperiodic configurations [3], features not being observed in the hydrogen-free structures [Ce/Fe]×n. Hydrogenation of Ce leads to a distinct reduction of the 4f-conduction band hybridization: the isotropic Ce-$L_{2,3}$ absorption spectra show a white-line profile very close to that of y-phase like Ce compounds pointing to significant relocalization of the 4f states with an occupancy close to 1, both at 300 K and 10 K. The $L_{2,3}$ XMCD spectra are particularly unusual and very different from those found for the non-hydrided multilayers: they vary distinctly (i) with temperature and (ii) with the *angle* Θ between the external magnetic field applied parallel to the incident x-ray beam and the layer normal (Fig.1). The branching ratio of the integrated XMCD intensities, $|I(L_2)/I(L_3)|$, varies between 2 at 300 K and about 10 at 10 K. The high-temperature value is similar to that of the cc-like Ce compound $CeFe_2$ and points to a considerable correlation of the Ce electronic configuration in the multilayers, in spite of its proximity to the y-phase. In contrast, the low-temperature value of the branching ratio compares

closely to that of $CeRu_2Ge_2$, a γ-Ce compound with well localized 4f states, and points to an increased localization of the Ce-4f states at low temperatures. The correlated nature of the Ce electronic structure at high temperatures permits the application of the sum rules [4] and hence to estimate the orbital and spin contributions of the 5d magnetic moments in the ground state from the L_2 and L_3 spectra: remarkably, the values of $\langle L_z^{5d} \rangle$ and $\langle S_z^{5d} \rangle_{eff} = \langle S_z^{5d} \rangle + 7/2\langle T_z^{5d} \rangle$ vary with $\sin\Theta$ (Fig.2). Since $\langle S_z^{5d} \rangle$ must be isotropic, the angular dependence of the XMCD signal (Fig.1) is due to the variation with Θ of the orbital momentum $\langle L_z^{5d} \rangle$ and of the magnetic dipole term $\langle T_z^{5d} \rangle$. The strong anisotropy of $\langle L_z^{5d} \rangle$ must contribute to the perpendicular magnetic anisotropy observed in the mulitilayer system [2]. At low temperatures, the sum rules are not applicable to the measured Ce-5d XMCD intensities, as a consequence of the increased localization of the 4f states [5].

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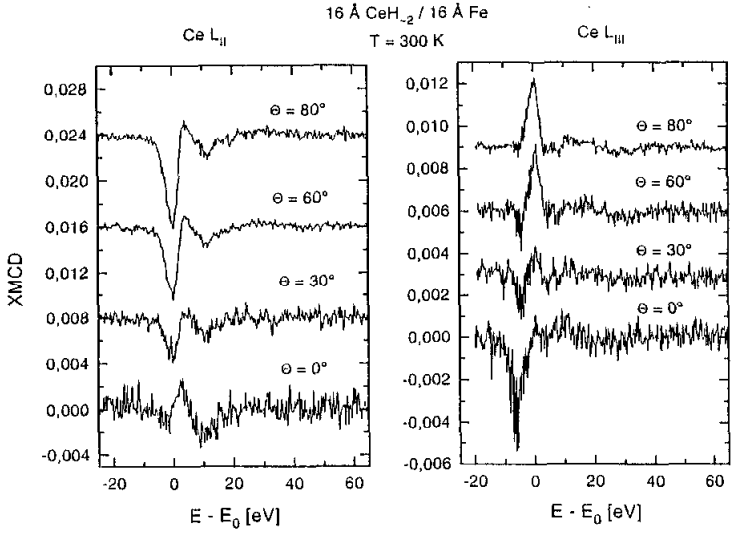

Fig. 1: XMCD spectra at the Ce-$L_{2,3}$ edges at 300 K for different angles Θ between the magnetic Field (H = ±1T) and the layer normal. X-ray beam parallel to H.

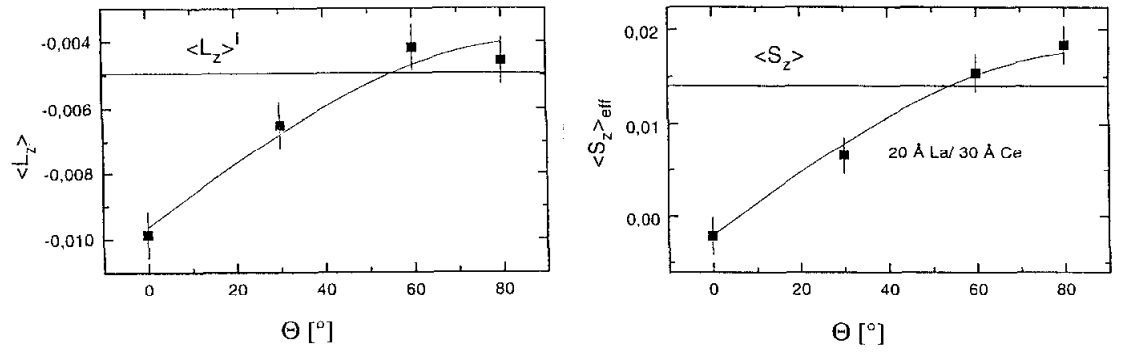

Fig. 2: Ce-5d orbital and effective spin moments of a multilayer [16ÅCeH₂/16ÅFe]×n at 300 K versus Θ. The solid curves denote the dependence A + Bsin Θ.