



	Experiment title: Local moments versus total magnetization in quasi two-dimensional CePt Kondo systems	Experiment number: He-3443
Beamline: ID12	Date of experiment: from: 10.12.2010 to: 20.12.2010	Date of report: 11-02-28
Shifts: 18	Local contact(s): Andrei Rogaley, Fabrice Wilhelm	<i>Received at ESRF:</i>
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Report:

The aim of the proposed experiments was to investigate the paramagnetic response of structurally ordered ultrathin CePt₅ surface alloys by XMCD at the Ce and Pt L_{2,3} edges, respectively. To this end, a few experimental challenges had to be met:

1) The surface alloy specimen preparation needs to be done in ultrahigh vacuum on single crystalline Pt(111) surfaces. Exposure to atmosphere during transfer to the measurement station constitutes a severe risk of chemical degradation of the specimens. We have successfully avoided the contamination of the thin film specimens by adding an epitaxial Pt capping layer.

2) Due to the very small thickness of the films investigated (≤ 4 nm) the fluorescence yield is fairly low and the film signal is easily overwhelmed by background emission and/or diffraction signals from the bulk substrate.

3) This is even more severe when investigating the Pt signal, since Pt related fluorescence emanates from a volume easily three orders of magnitude larger than the film. In order to obtain a Pt related dichroic signal, we have therefore prepared a CePt₅ film (plus Pt capping layer) on Pd(111) as a second sample.

Due to the different detection schemes available at ID12, useful dichroic signals were obtained at both Ce and Pt L_{2,3} edges, respectively. The experience gained with the two specimens clearly demonstrates the feasibility and the potential of this kind of experiments for a refined understanding of magnetism in Ce alloys.

A first set of measurements was performed on a CePt₅ film of approx. 4 nm thickness (9 unit cells along the hexagonal axis), capped with ~ 1 nm (4 atomic layers) of Platinum, which

grew epitaxially according to a cross check with LEED. The total amount of Ce corresponds to just $3.3 \cdot 10^{15}$ atoms/cm² or, equivalently, 2.25 monolayers at the atomic density of Pt(111). The Ce L_{2,3} XANES (Fig. 1) reveals a clean, metallic spectrum, characteristic of a 4f¹ ground state configuration [1]. Taking these spectra along with XMCD was only possible using the 35 channel energy resolving detector, tuned such as to optimally suppress the large background fluorescence yield of the substrate crystal. The simultaneously measured photodiode TFY data revealed dichroism of comparable shape, but NEXAFS dominated by substrate contributions. Compared to similar data on the related compound CePtSn [2], the dichroic signal is similar in shape and fairly strong (~ 2 % of the edge jump).

According to M(H) data recorded at T = 7 K (not shown), the film is paramagnetic. $M_{6T}^{-1}(T)$ data, as shown in Fig. 2 (χ^{-1} , essentially) clearly deviate from a simple 1/T dependence. If a direct coupling to the 4f moments is assumed, this can be explained by the hexagonal crystal field splitting at low temperatures, which has been observed at the Ce M_{4,5} edges. Additionally, deviations from a linear M(H) dependence at 6 T have to be taken into account, especially at the lowest temperatures.

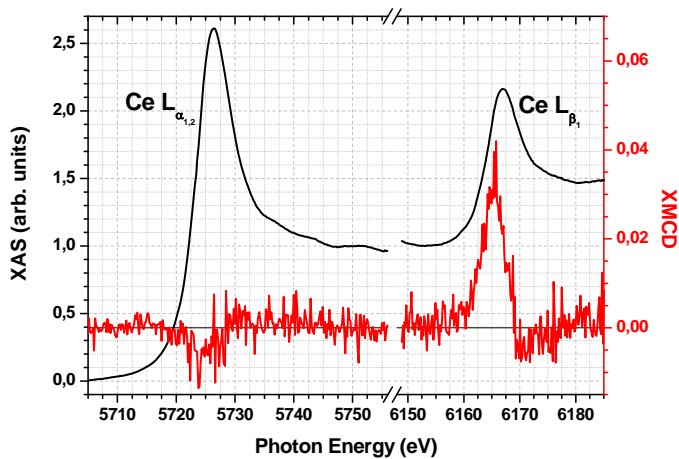


Fig. 1: Ce L_{3,2} XANES and XMCD for ~ 9 u.c. CePt₅/Pt(111) 6 T, 7 K, 15° incidence

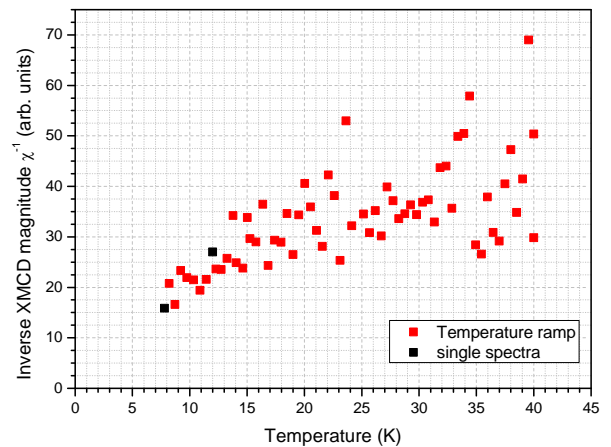


Fig. 2: Temperature dependence of the inverse XMCD magnitude for ~ 9 u.c. CePt₅/Pt(111).

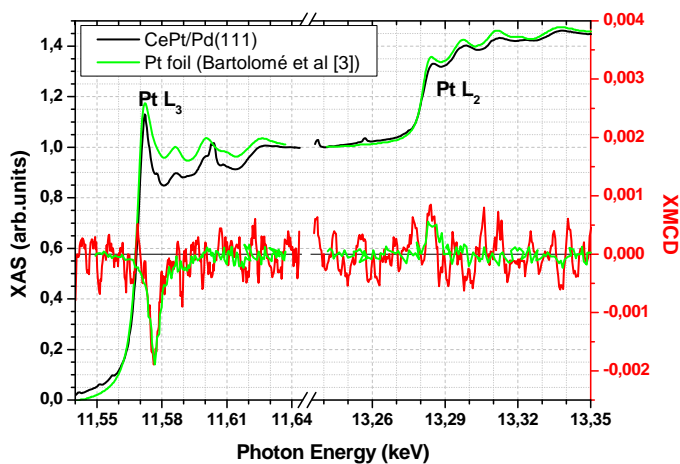


Fig. 3: Pt L_{3,2} XANES and XMCD for ~3 u.c. CePt₅/Pd(111)

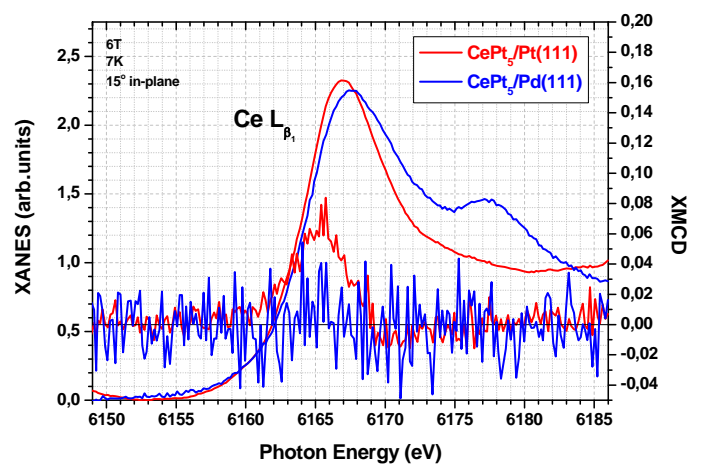


Fig. 4: Ce L₂ XANES and XMCD in comparison of the two samples

To test the detectability of Pt L_{2,3} XMCD at this film thickness, a second film of nominally 3 unit cells CePt₅ was prepared on Pd(111), with additional Pt seed and capping layers. Pt NEXAFS and XMCD could indeed be measured, this time using the photodiode (Fig. 3), while the energy dispersive detector was unavoidably overwhelmed by Pd M_{4,5} emission. The Ce L₂ line shape proved different, though (considerable 4f⁰ weight), and the associated dichroism is considerably reduced (Fig. 4).

The change in line shape might relate to the reduced thickness, for which we have found an increased 4f⁰ spectral weight at the Ce M_{5,4} edges. However, at this time we cannot entirely exclude some Pd-Pt interdiffusion at the interface to have occurred, potentially leading to Ce-Pd bond formation which is known to favor the mixed valence state in Ce.

The Pt L_{2,3} NEXAFS is visibly different from the one recorded on fcc Pt, as a consequence of the hexagonal structure of the alloy film. The corresponding XCMD signal (Fig. 3) appears to be of the same size as in polycrystalline Pt [3].

Altogether we consider the beamtime as a success, given the encouraging results and recalling the experimental challenges. The 18 shifts allocated were entirely used (and badly needed) the only “incident” having been an interruption for some hours due to unexpected computer communication problems in one night.

References:

[1] J. Ph. Schillé *et al.* Physica B **199&200** (1994) 563-566

[2] B. Janoušová *et al.* Physica B **359-361** (2005) 127-129

[3] J. Bartolomé *et al.* Phys. Rev. B **80** (2009) 014404