

**Experiment title:**Resonant X-ray scattering investigation of the magnetic ordering in thin films of UPd<sub>2</sub>Al<sub>3</sub>.**Experiment number:**  
**HE-299****Beamline:**

ID20

**Date of experiment:**

from: 07-May-98 to: 12-May-98

**Date of report:**

7.10.98

**Shifts:**

18

**Local contact(s):**

Christian Vettier

*Received at ESRF:***Names and affiliations of applicants (\* indicates experimentalists):**

A. Hiess\*, N. Bernhoeft\*, ILL, BP156, 38042 Grenoble, France

S. Langridge\*, ISIS, Rutherford Appleton Lab., Chilton, Didcot, OX1 1 OQX, UK

G. H. Lander\*, European Commission, ITU, Postfach 2340, 76125 Karlsruhe, Germany

M. Jourdan\*, M. Huth, H. Adrian, Job.-Gutenberg-University, 55099 Mainz, Germany

**Report:**

During our first experiment on ID20 in 1997 (HE-71) two films with thicknesses of 800Å and 1600Å of the magnetic heavy fermion superconductor UPd<sub>2</sub>Al<sub>3</sub> were investigated by resonant magnetic x-ray scattering. We here report on the second experiment using thinner samples with thicknesses of 100Å, 200Å, 400Å and 800Å. All samples were epitaxially grown in Mainz on LaAlO<sub>3</sub> (1 1 1) substrates by electron co-evaporation. They show an anomaly at about 12K in the electrical resistivity which can be attributed to the onset of magnetic order. All - except the thinnest film - become superconducting at low temperatures  $T < 2K$ .

The magnetic scattering observed at the antiferromagnetic Bragg positions (0 0 1/2) and (0 0 3/2) shows that the magnetic ordering is the same in the films as in the bulk. However, the ordering temperature is reduced from  $T_c = 14K$  for the bulk samples to about  $T_c = 12K$  in the films (Fig. 1), as expected from the resistivity data.

The inverse of the peak width observed in L-scans and O-scans performed around the magnetic Bragg reflections (Fig. 1) is a measure for the magnetic correlation lengths in the direction of the film growth (hexagonal c-axis) and in the plane of the films, respectively (Fig. 1). It has been pointed out before (see report HE-71) that the energy-width of the magnetic signal at the absorption edge can be related to the spacial extent

of the magnetic ordering in real space [ 1]. From analyzing the  $\Theta$ -, L- and energy-width of the magnetic signal the following microscopic model for the magnetic order has been established (Fig. 2) [2]: (A) Magnetic order initially develops at the surface and for  $T < T_N$  penetrates into the film. (B) The magnetic ordering penetrates the whole film at low T and is restricted by the film thickness only. (C) The magnetic correlation length (magnetic domain size) in the plane of the film is approximately equal to the film thickness in all films at low T.

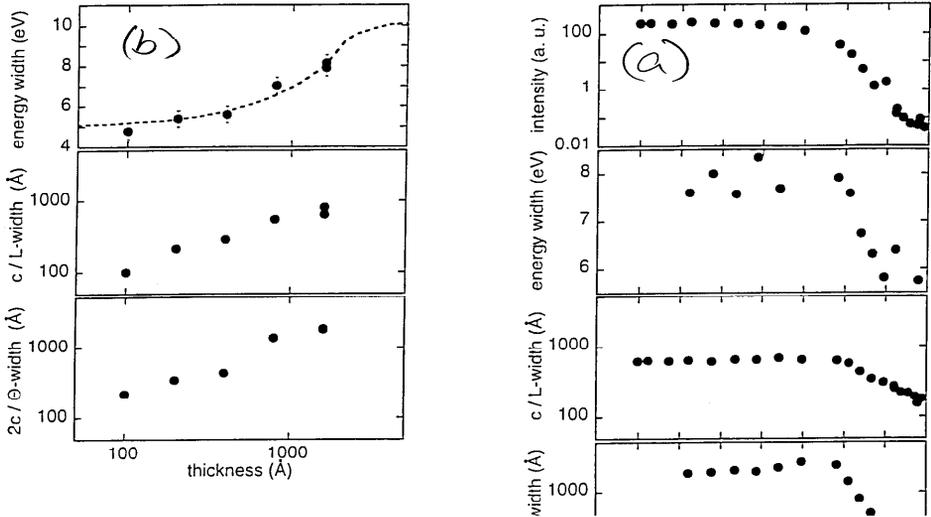


Fig. 1: (a) magnetic intensity, energy width,  $2c/\Theta$ -width,  $c/L$ -width vs. temperature as deduced from the  $(0\ 0\ 1/2)$  magnetic reflection measured on a  $1600\text{\AA}$  thick film. (b) energy width,  $2c/\Theta$ -width,  $c/L$ -width at  $T=4\text{K}$  vs. thickness.

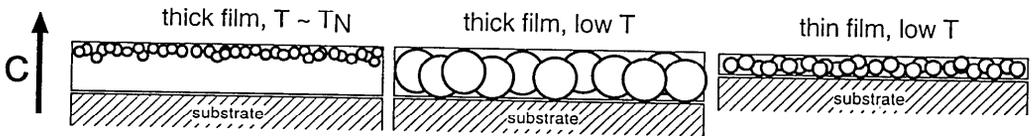


Fig. 2: Proposed model for the magnetic ordering in UPd<sub>2</sub>Al<sub>3</sub> thin films (Note that the substrate thickness is much greater than the film thickness).

*Publications related with this work:*

[1] N. Bernhoeft et al., Physical Review Letters, in press (1998)

[2] A. Hiess et al., Physica B, in press (1998), conference proceedings SCES '98