	Experiment title:	Experiment number:
ESRF	Soft X-Ray Diffraction Studies of Spiral Magnetic Structures in RFe$_4$Al$_8$ with R = Ho and Dy	HE-1547
Beamline: ID08	**Date of experiment:** from: 05 Nov 2003 to: 11 Nov 2003	**Date of report:** 24th Feb 2005
Shifts: 18	**Local contact(s):** Dr. Peter BENCOK	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Prof. Peter D. Hatton[1]

Dr. Stuart B. Wilkins[2,3]

Mr. Thomas A. W. Beale[1]

Mr. Philip D. Spencer[1]

1. University of Durham, UK
2. Insititute of Trans-Uranics, Karlsruhe, Germany
3. ESRF

Report:

Soft x-ray resonant scattering has been used to examine the charge and magnetic interactions in the helical antiferromagnetic compound DyFe$_4$Al$_8$. By tuning to the Dy $M_{IV,V}$ absorption edges and Fe $L_{II,III}$ absorption edges we can directly observe the behavior of the Dy 4f and Fe 3d electron shells. Magnetic satellites surrounding the (110) Bragg peak were observed below the ordering temperature of 60 K. Our results demonstrate the incommensurate AFM ordering of the Dy and Fe sublattices as a function of temperature. The (001) Bragg peak was identified, and then the sample was cooled. At base temperature altering the energy on this Bragg peak identified the energy corresponding to the maximum resonance of the M_V edge.

Using incident x-rays of this energy, multiple satellites were found in the [110] direction around the (110) Bragg peak (fig. 1). Scans in reciprocal space in the [110] direction corresponded to $\theta,2\theta$ scans. This avoided scanning in the χ direction, which is unreliable in the ID08 chamber. As well as peaks appearing at positions corresponding to those previously observed by neutrons $n\tau$ peaks, where n = odd, we also observed peaks with n = even observed by resonant scattering at the Dy L edges. In addition we observed a peak corresponding to the (0,0,5τ) peak from the origin. For all of these peaks τ = 0.133. We performed high resolution energy scans of the (1,1,0) Bragg peak (fig. 2a), and (1-τ ,1-τ ,0) satellite peak (fig. 2b) through the Dy $M_{IV,V}$ edges on the ID08 beamline, with $\delta E/E \approx$ 50meV at 20 K. These energy scans show a strong resonance at the M_V edge and a much weaker resonance at the M_{IV} edge.

The resonance of the satellite peak at the M_V edge was split into two strong peaks at 1293 eV and 1296 eV, with a possible shoulder on the high energy side of the peak at 1296 eV. The Bragg peak showed a similar resonance, but with a weaker resonant enhancement, and a broader resonance. Proportionally the M_{IV} resonance is more intense on the Bragg peak than on either satellite.

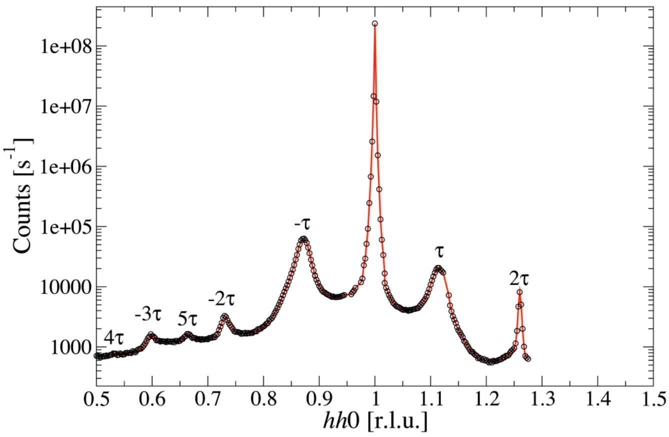

Figure 1 Scattered x-ray intensity as a function of incident photon energy at the constant wavevector of *(a)* **Q** = (110) at 20 K, *(b)* **Q** = $(1-\tau, 1-\tau, 0)$ at 20 K, and *(c)* **Q** = $(1-\tau, 1-\tau, 0)$ at 28K, through the Dy M_{IV} and M_V edges.

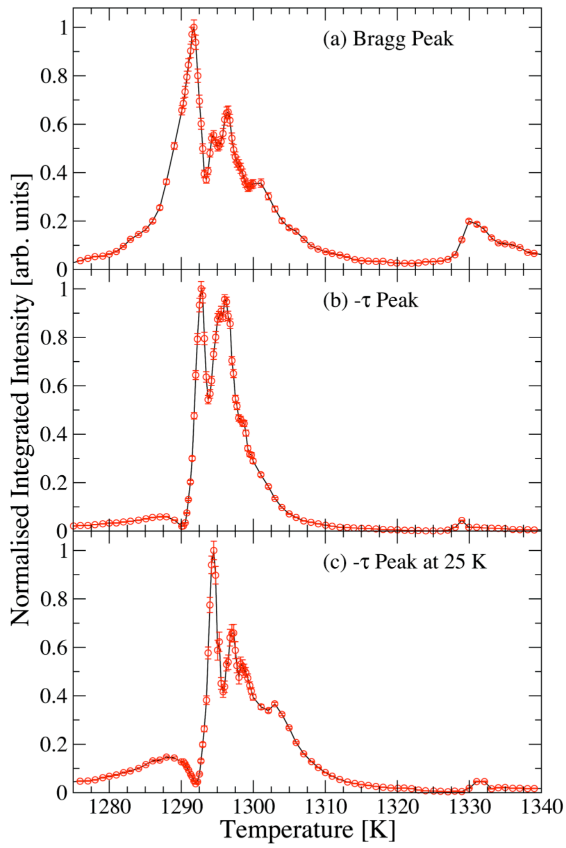

Figure 2 Superlattice peaks measured at the Dy M_V and M_{IV} edges.

It has been suggested a number of times that the iron in these systems orders at ~100 K. To test this we tuned the energy to the Fe *L* edges. Because of the reduction in the size of the Ewald sphere at this energy, it is only possible to reach the (1-3τ, 1-3τ, 0) superlattice peak at the Fe *L* edges, all the other peaks apart from the (5τ, 5τ, 0) require $2\theta > 180$. We did not observe the (0,0,5τ) peak which we attribute to it's very low intensity. We could only observe the (0,0,3τ) magnetic peak at the Fe L_{II} and L_{III} edges. No resonance was observed at the Fe L_I edge. The resonance shows a single peak corresponding to the Fe L_{III} edge, and a very weak peak at the Fe L_{II} edge.

Our results demonstrate the advantages of atomic selective magnetic resonance tecchniques. Soft x-ray resonant diffraction is particularly useful due to the extremetly strong resonant enhancement of both the 3*d* electrons in Fe and the 4*f* electrons in Dy.