	Experiment title: **Magnetic domain imaging of a $GdVO_3$ single crystal as probed by resonance magnetic X-ray scattering**	**Experiment number**: HS3441
Beamline: ID20	**Date of experiment**: from: 28/11/2007 to: 4/12/2007	**Date of report**: 29/02/2008
Shifts: 18	**Local contact(s)**: Luigi Paolasini	*Received at ESRF:*

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Report:

The perovskites RVO_3 (R = rare-earth or Y) are typical t_{2g} electron systems that have attracted much attention in the past few years due to their intriguing magnetic properties which result from the quasi one-dimensional orbital character and a strong interplay between orbital and spin degrees of freedom [1-5]. A typical example was found recently: $GdVO_3$ shows multiple field-induced magnetic phase transitions at 1.8 K and a magnetisation reversal related to a magnetic memory effect at about 8 K [6].

In order to unravel the anomalous magnetic properties of this compound, we have performed magnetic X-ray scattering at the instrument ID20. The single crystal $GdVO_3$ has been aligned with the surface parallel to (011) and (100) directions and mounted in the 12 T vertical field split coil cryomagnet with magnetic field applied along (100). This orientation of the crystal allows to access reflections close to or within the *bc*-plane. With the magnetic field H applied along the (100) direction, anomalous magnetic properties had been reported [6]. Magnetic scattering was observed at the V *K*-edge (5.465 keV), however with little resonance enhancement.

On the other hand, strong resonant scattering was found at the Gd *L2*-edge (7.932 keV). At temperatures below 10 K, the Gd moments were seen to order in 4 different competing magnetic phases apart from a forced ferromagnetic state at applied field > 3 T. We have performed *k*-scans at 2.4 K in different magnetic fields and typical results obtained for both π-σ and π-π channels are shown in Fig. 1. At 2.4 K and zero field, the Gd moments order with the propagation vector (0, 0.833, 0) (AF1 phase) which does not change significantly up to 0.75 T. At 1 T, the propagation vector shifts to (0, 0.84, 0) (AF2 phase). This corresponds well with a jump observed at around 0.9 T observed both in the magnetisation and magnetostriction data (see inset of Fig. 1a). The change in the magnetic structure from AF1 to AF2 is also reminescent by the observation of a sudden increase (decrease) of the intensity in the π-σ (π- π) channels, which indicates that, in AF2, the modulated Gd moment component becomes restricted to the *bc*- plane and there is only a ferromagnetic moment component along (100). At around 1.75 T, the third magnetic phase (AF3) with two distinct peaks located at around (0, 2.793, 2) and (0, 2.892, 2) in the π-σ channel appeared. These two peaks were slightly moved to higher *k* values with increasing the applied field. At 2.75 T, the compound changes to a new magnetic phase with propagation vector of about (0, 0.759, 0) (AF4) before reaching the forced ferromagnetic state (F) at 3.25 T. The positions of the three transitions AF2-AF3, AF3-AF4, and AF4-F observed in the magnetic X-ray scattering data are in good agreement with the magnetisation and magnetostriction data.

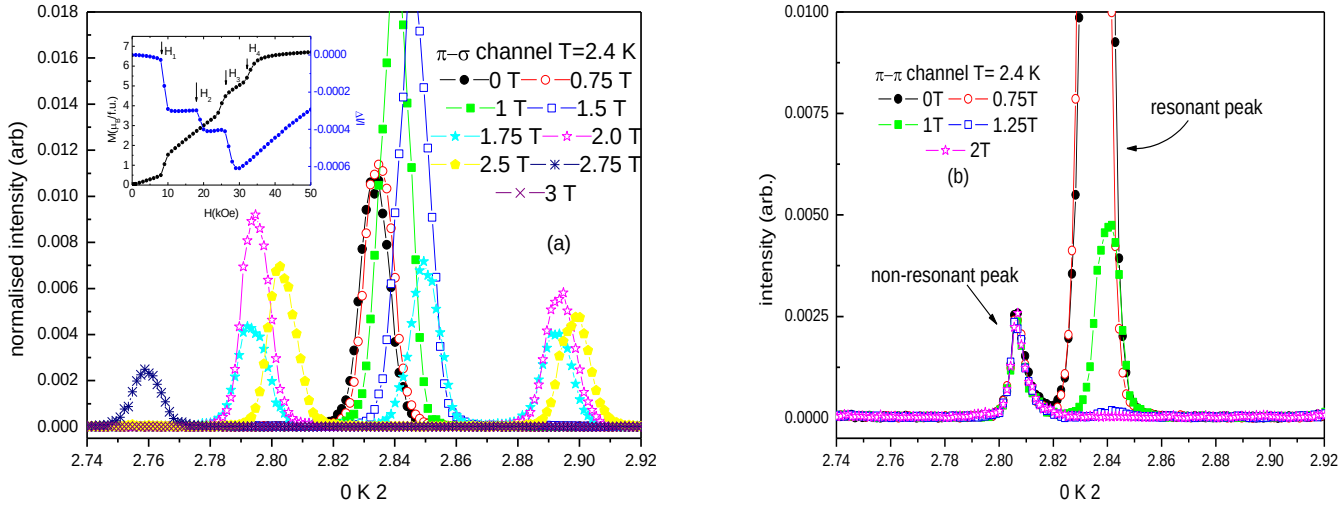

Fig. 1 (colors) : Magnetic X-ray scattering signals obtained from the π-σ channel (a) and π-π channel (b) with the k-scan at 2.4 K. The inset in (a) shows the results of the magnetisation and the magnetostriction curves measured at 1.8 K.

The competing magnetic phases can also be seen from the measurements of the *k*-scan with temperature at different magnetic fields of 0, 10, 20, and 30 kOe. In Fig. 2, we present the phase diagram of the $GdVO_3$ compound as derived from the magnetic X-ray scattering. We have discovered that, when warming the sample in zero or small magnetic field, the Gd moments first transform from AF1 to AF4 phase at $T_1 \approx 7$ K before becoming paramagnetic (P) at $T_2 \approx 8.0$ K. The small temperature window of 1.0 K between T_1 and T_2, in

which the AF4 phase exists, was not detected previously (Ref. 6). However, our new magnetisation data (not shown) indicate that the magnetic memory effect as well as the magnetisation reversal seems to occur also at T_1.

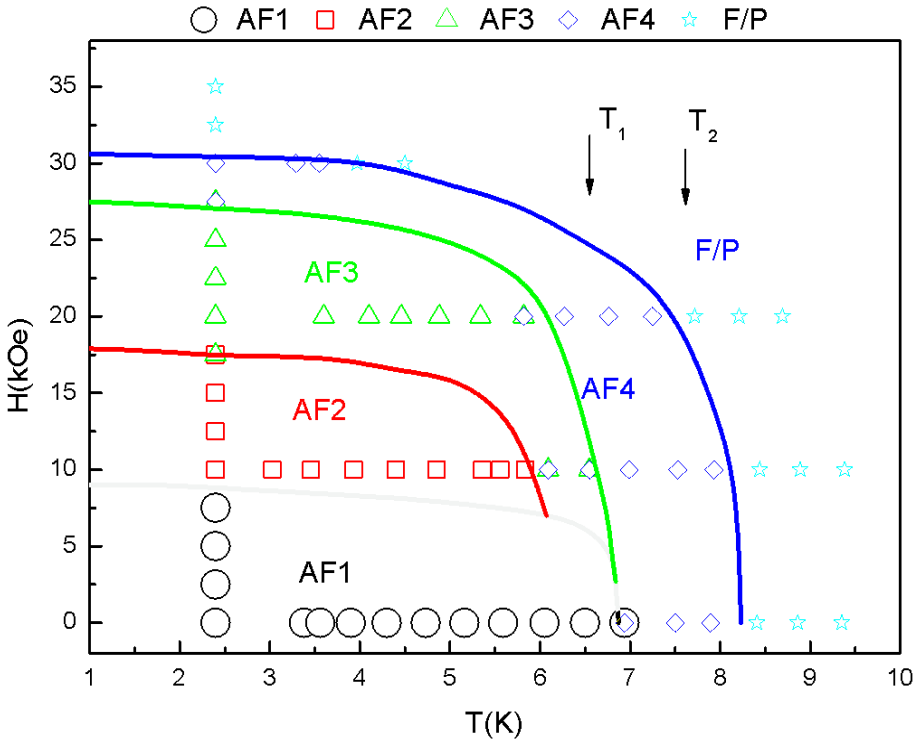

Fig. 1 (colors): Magnetic phase diagram for the Gd magnetism in a $GdVO_3$ single crystal as derived from magnetic X-ray scattering. The magnetic field was applied along the a-axis, the symbols are experimental data, the lines separating the phases are guide to the eyes. The measurements were carried out with increasing temperature. Definition of AF1, AF2, AF3, and AF4 can be found in the text.

Due to the weak signal and within the beam time of 18 shifts, we were unable to explore the V magnetism. Moreover, the present orientation of the crystal does not allow to go to the (0, 0, 1) propagation vector which was found by our single crystal neutron diffraction the ordering of the V in between 118 K and T_2 = 8.0 K. Here, it is important to know how the V moments ordered and their response in regard to the change in the magnetic structure of the Gd moments particularly at T_1. The continuation of the experiment on a newly oriented crystal with the surface normal to (001) direction to probe the V magnetism is required in order to unravel the intriguing magnetisation reversal and the magnetic memory effect.

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