EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Resonant X-ray scattering of multiferroic RE-Mn_2O_5 (RE = Tb, Ho, Dy)	**Experiment number**: HE2171
Beamline: ID20	**Date of experiment**: from: 03/05/2006 to: 09/05/2006	**Date of report**: 20/08/2006 *Received at ESRF:*
Shifts: 18	**Local contact(s)**: B. Janousova	

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Report:

$TbMn_2O_5$ can be indexed in Pbam (n°55) Orthorhombic group, with two Mn ions in the unit cell in 4f and 4h positions respectively. They are organized in a complex network of $Mn^{4+}O_6$ octahedra and $Mn^{3+}O_5$ trigonal bipyramids giving rise to several competing magnetic interactions and in turn to an exotic spin structure.

In particular, this material is know to undergo a sequence of magnetic phase transitions (in zero external magnetic field):

i) incommensurate spin structure (ICM1) at T=42K with a propagation vector (.49 0 .27),

ii) commensurate (CM, see fig.1) structure with propagation vector (1/2 0 1/4) at T~38K,

iii) incommensurate structure (ICM2) at T~24K characterised by a propagation vector of (.47 0 .31) [1].

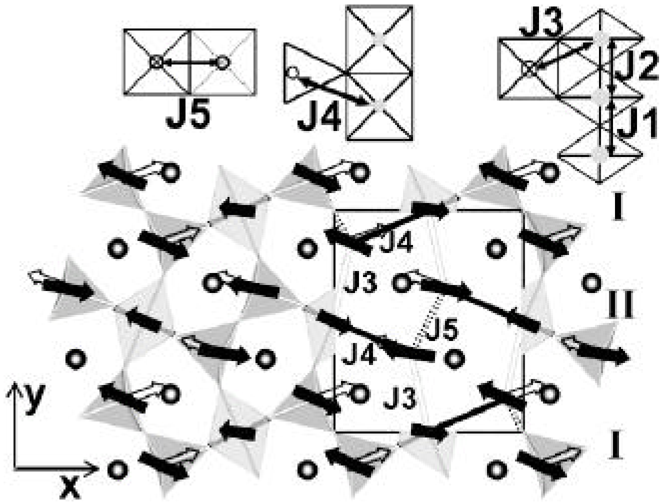

Fig.1: magnetic structure in the CM phase, as deduced by neutron measurements [1]. Spins are indicated by the black arrows. White arrows are a possible pattern of displacements responsible for the ferroelectricity. The five competing magnetic

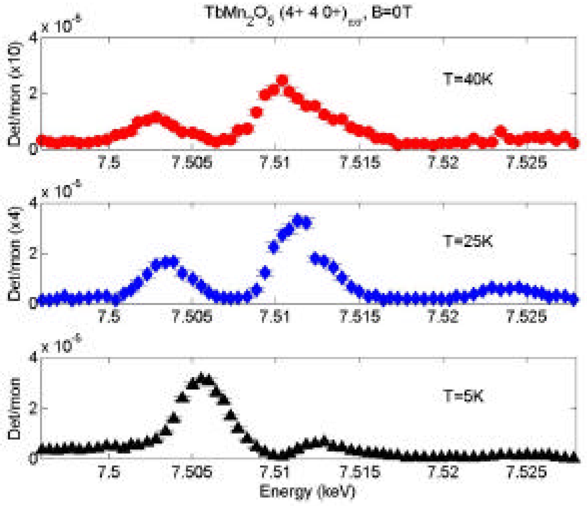

Fig. 2: magnetic energy spectra in zero magnetic field for the (4 4 0) + (q_x 0 q_z) in the three magnetic phases: ICM1 top, CM center, ICM2 bottom.

We have investigated a TbMn$_2$O$_5$ single crystal by Resonant X-Ray Scattering on ID20, using the horizonthal scattering geometry in EH2; the sample was mounted inside the 10T superconducting magnet with the c axis vertical, the specular direction being (110). A single crystal of Au (222) was used as a polarisation analyser. After cooling the sample in zero field we detected a magnetic signal in each of the three phases. The magnetic signals coming from the different phases coexist at each of the two transitions (ICM1-CM and CM-ICM2), as already reported by neutron measurements [2]. The energy spectrum of the resonance is shown in fig.2; top panel ICM1, central panel CM, bottom panel ICM2 signals, respectively, for the zero field measurements of the (4 4 0)+(q_x 0 q_z) magnetic reflection.

Two main resonant features are clearly visible; the signal is at least 2 times stronger in the CM phase than in the ICM1; the magnetic resonance is even stronger in the ICM2. Note that in the ICM2 phase the magnetic signal shows a big energy shift compared with the other two phases and a different ratio of the two peak intensities. At the moment we are performing magnetic calculations by means of the FDMNES program to give an interpretation of the magnetic spectrum in each of the different phases. No distortions were detected on charge diffraction peaks in the present experiment, although the strict geometrical constrains due to the sample environement allowed us to reach only a small number of reciprocal lattice points.

By applying a magnetic field up to 10 T at different temperatures we have determined the tentative phase diagram of fig. 3.

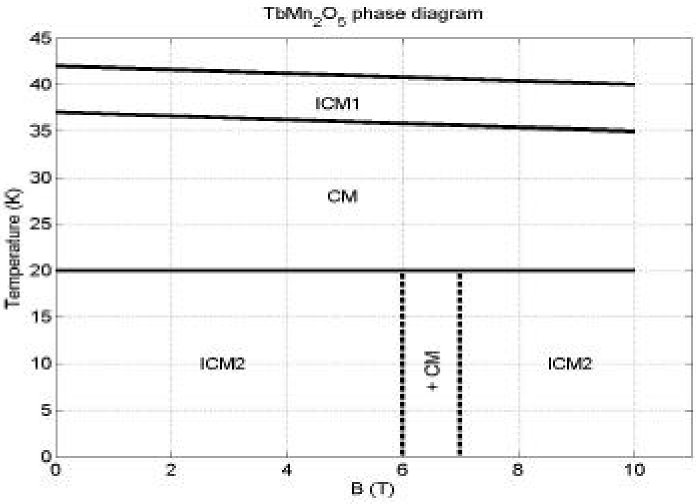

Fig. 3: tentative phase diagram of TbMn$_2$O$_5$

ICM1 and CM magnetic phases are robust with respect to an external magnetic field while in the low temperature region of the phase diagram a coexistence is induced by a fields in the range 6-7 T. To our knowledge this is the very first time that this effect has been detected in TbMn$_2$O$_5$ and it matches with the sign change of the polarisation vector at low T, as reported in [3].

This fact suggests a strong relationship between the magnetism and the electric polarisation in this compound and it is consistent with pressure measurements performed on other compound of the serie (RE = Ho, Dy) [4].

In this experiement we have confirmed the interplay between electric and magnetic degrees of freedom in this material, at least in the low temperature region of the phase diagram.

Further investigation is necessary to determine the origin of the energy features in the resonant magnetic signal and to restrict hypothesis on the nature of the magnetic interactions in the compound.

For this reason we consider very important to perform an azimuth measurement in the vertical scattering geometry: the open geometry and the azimuth degree of freedom are necessary to uniquely address the nature of the resonant signal detected here.

[1]: Chapon L. et al., PRL 93 (2004), 177402
[2]: Kobayashi S. et al., JPSJ 73 (2004), 3439
[3]: Hur N. et al., Nature 429 (2004), 392
[4]: C. R. Dela Cruz et al., JMMM to be published