Moscow State University, Moscow, 119991 (Russia). [c]*Faculty of Science and Technology, Tokyo University of Science, Noda, Chiba 278-8510, (Japan).* [d]*Diamond Light Source, Harwell Science and Innovation Campus, OX11 0DE, (UK).* E-mail: dmitrien@crys.ras.ru

It is demonstrated how diffraction methods can be used for experimental determination of the sign of the Dzyaloshinskii-Moriya interaction (DMI) in antiferromagnetic crystals with weak ferromagnetism. Previous attempts to measure this sign are carefully analyzed. It is shown that in this case the vector of DMI correlates with the sign of the *local chirality* of centrosymmetric crystal structure. In fact, the canting of atomic moments can be considered as a result of alternating right-hand and left-hand rotations of moments in accordance with alternating local chirality inside the crystal unit cell.

Three different experimental techniques sensitive to the DMI sign are discussed: neutron diffraction, Mössbauer γ-ray diffraction, and magnetic (resonant or non-resonant) x-ray scattering.

In particular, it is demonstrated that the DMI sign can be directly extracted from interference between magnetic X-ray scattering, sensitive to the phase of antiferromagnetic order, and charge scattering, sensitive to the phase of crystal structure. Classical examples of hematite (α-Fe_2O_3) and $FeBO_3$ crystals are considered in detail (see [1] for preliminary consideration). This interference distorts strongly the azimuthal dependence of forbidden reflections and was recently observed in hematite [2]. However, the results of [2] cannot be directly used for the sign determination because the orientation of the weak ferromagnetic moment was indefinite in that work. The application of external magnetic field, fixing the orientation of the weak ferromagnetic moment and (owing to the DMI) fixing the phase of antiferromagnetic order relative to the crystal structure, will be crucial for this type of experiments.

The expected details of azimuthal dependence are simulated using FDMNES codes [3] for x-ray scattering amplitude the near absorption edges of magnetic atoms. We hope that the DMI sign of $FeBO_3$ will be measured in July at XMAS beamline in Grenoble. Results for more complicated cases of the DMI in crystals of La_2CuO_4 and MnSi types are also presented.

Two other possible techniques, neutron diffraction and Mössbauer γ-ray diffraction, sensitive to the DMI sign, are carefully discussed in comparison with magnetic x-ray scattering. Advantages and disadvantages of different techniques are analyzed. For example, the analysis of neutron data is straightforward whereas for resonant x-ray diffraction one needs rather sophisticated programs [3].

This work was supported by the Russian Foundation for Basic Research (project 10-02-00768) and by the Program of Fundamental Studies of Presidium of Russian Academy of Sciences (project 21).

[1] V. E. Dmitrienko, E. N. Ovtchinnikova, J. Kokubun, K. Ishida, *JETP Lett.* **2010**, *92*, 383-387 www.jetpletters.ac.ru/ps/1909/article_28995.shtml. [2] J. Kokubun, A. Watanabe, M. Uehara, Y. Ninomiya, H. Sawai, N. Momozawa, K. Ishida, V.E. Dmitrienko, *Phys. Rev. B,* **2008**, *78,* 115112. [3] Y. Joly, *Phys. Rev. B,* **2001**, *63,* 125120; FDMNES codes can be found at www.neel.cnrs.fr/fdmnes.

Keywords: X-ray magnetic scattering, neutron diffraction, dzyaloshinskii-moriya vector

MS96.P04

Acta Cryst. (2011) A**67,** C801

Magnetic structures of the Co^{+2} doped $Mn_{1-x}Co_xWO_4$ Wolframites

I. Urcelay-Olabarria,[a] E. Ressouche,[b] J.L. García-Muñoz,[c] V. Skumryev,[d] [a]*Institut Laue Langevin, 6 rue Jules Horowitz BP 156, F-38042 Grenoble cedex 9, (France).* [b]*SPSMS, UMR-E CEA/UJF-Grenoble 1, INAC, Grenoble, F-38054, (France).* [c]*Instituto de Ciencia de Materiales de Barcelona, Campus universitari de Bellaterra, E- 08193 Bellaterra, (Spain).* [d]*Institut Catala de Recerca i Estudis Avancats, Barcelona, (Spain).* E-mail: urcelay@ill.fr

New materials, in which magnetic and ferroelectric long range order coexist and strongly interact, have become of great interest due to the fact that magnetism can be controlled by electric fields and vice versa. The interest in these magnetoelectric multiferroic materials has been enhanced since a new class of multiferroics have been discovered: materials the complex magnetic structure of which induces ferroelectricity.

It is known that $MnWO_4$ belongs to this new class of multiferroics and exhibits large magnetoelectric effects [1-3]. When decreasing the temperature, it undergoes three successive phase transitions to three different long-range antiferromagnetic states [1,2]. Below T_N=13.5 K moments order in the *ac* plane, the spins are collinear and sinusoidally modulated. This phase is the so called AF3 and is paraelectric. The AF2 phase appears in the interval 7.5 K < T <12.5 K, presents an additional magnetic component along *b* and is ferroelectric. A spontaneous polarization along *b* axis coexists with an elliptical spiral-spin structure. These two structures have the same propagation vector: **k**=(-0.214, ½, 0.457). Below 7.5 K the system is collinear (*ac* plane) and commensurate with **k**=(±1/4,1/2,1/2) (AF1). This succession of magnetic states at low temperature is a consequence of geometrical magnetic frustration effects in the intrachain and interchain magnetic interactions.

By substituting Mn^{+2} ions by isovalent M^{+2} (M: transition metal) the magnetoelectric properties change [3, 5, 6]. Doping the sample with Co^{2+} is specially interesting: this doping is the only known that strongly stabilizes the multiferroic magnetic phase. According to preliminary data on powder samples [5] the incommensurate multiferroic AF2 phase is expected to substitute the commensurate AF1 ordering at low temperature for x>0.03.

We have studied the magnetic structure of the 10% Co doped composition by single crystal neutron diffraction. We confirm the disappearence of the paraelectric AF1 phase which is substituted by the multiferroic AF2* phase, which is different from the AF2 phase of the pure compound. Moreover, it was observed that at this doping the orientation of the magnetic moments in the AF3 magnetic phase changes as well. In addition, an external magnetic field was applied along the *c* axis and modifications of the magnetic structure of the multiferroic phase were studied: the rotation plane of the magnetic moments flips and the spins lay perpendicular to the applied field. This magnetically induced transition transforms a multiferroic phase into another one in which the electric polarization is also flipped compared polarization appearing in the zero-field structure. To summarize, we confirm that substituting Mn^{+2} by Co^{+2} is an efficient mechanism to stabilize the multiferroic phase in the $Mn_{1-x}M_xWO_4$ family, and that the application of magnetic fields modifies the cycloidal and polar orderings.

[1] G. Lautenschläger et al., *Phys. Rev.* **1993,** *B 48,* 6087. [2] H. Sagayama et al., *Phys. Rev.* **2008,** *B* 77, 220407(R). [3] K. Taniguchi et al*., Phys. Rev. Lett.* **2009,** *102*, 147201. [4] F. Ye et al, *Phys. Rev.* **2008,** *B 78*, 193101. [5]Y.-S. Song, J.-H. Chung, J.M.S. Park, Y.-N. Choi, *Phys. Rev.* **2009,** *B 79*, 224415.

Keywords: multiferroics, magnetic structures, single crystals

MS96.P05

Acta Cryst. (2011) A**67,** C801-C802

Structural, magnetic and magnetocaloric properties of $CoMnGe_{1.95}Ga_{0.05}$

Yalcin Elerman,[a] Ilker Dincer,[a] Helmut Ehrenberg,[b] Tony Bell[c] [a]*Department of Egineering Physics, Ankara University, Ankara, Turkey,* [b]*Leibniz-IFW, Dresden, (Germany).* [c]*DORIS-III B2 beamline*