DF 8: Multiferroics IV (Joint Session of MA, DF, DS, KR, TT)

Time: Tuesday 10:45–12:15 Location: HSZ 04

DF 8.1 Tue 10:45 HSZ 04

Polarization and magnetization dynamics of a field-driven multiferroic structure — •Alexander Sukhov[1], Chenglong Jia[1], Paul P. Horley[2], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06120 Halle/Saale, Germany — [2]Centro de Investigation en Materiales Avanzados, S.C. (CIMAV), 31109 Chihuahua, Mexico

A multiferroic chain with a linear magnetoelectric coupling induced by electrostatic screening at the ferroelectric/ferromagnet interface [1] is considered. We study theoretically the dynamic ferroelectric and magnetic response to external magnetic and electric fields by utilizing an approach based on coupled Landau-Khalatnikov and finite-temperature Landau-Lifshitz-Gilbert equations. Additionally, we make comparisons with Monte Carlo calculations. It is demonstrated [2] that for material parameters corresponding to $BaTiO_3$/Fe the polarization and the magnetization are controllable by oscillating external magnetic and electric fields, respectively.

[1] T. Cai, S. Ju, J. Lee, N. Sai, A.A. Demkow, Q. Niu, Z. Li, J. Shi and E. Wang, Phys. Rev. B **80**, 140415(R) (2009). [2] A. Sukhov, C.L. Jia, P.P. Horley and J. Berakdar, J. Phys.: Condens. Matter **22**, 352201 (2010).

DF 8.2 Tue 11:00 HSZ 04

Rare-earth induced magnetoelectric effect in multiferroic $TbMn_2O_5$ — •Naëmi Leo[1], Dennis Meier[2], Roman V. Pisarev[3], Sang-Wook Cheong[4], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn — [2]UC Berkeley, USA — [3]Ioffe Institute, St. Petersburg — [4]Rutgers University, USA

The presence of magnetic frustration and multi-dimensional magnetic order parameters leads to remarkable effects like magnetically induced ferroelectricity. Such a particularly interesting compound is $TbMn_2O_5$ due to the associated magnetic-field controllable electric polarization. The gigantic magnetoelectric coupling originates in the presence of three independent ferroelectric contributions, which can be separatedly accessed by optical second harmonic generation (SHG). Two of these contributions are related to the manganese Mn^{3+} and Mn^{4+} magnetism. The third one is attributed to the spin arrangement of the Tb^{3+} sublattice which also mediates the intricate field-dependent cross-coupling. We confirm this model by measurements taken on isostructural YMn_2O_5 with non-magnetic Y^{3+} ions.

Also we perform spatially resolved domain topography to show that the magnetic-field induced polarization reversal in $TbMn_2O_5$ does not include domain wall motion but is indeed due to a reversal of only one ferroelectric contribution.

This work was supported by the DFG through SFB 608.

DF 8.3 Tue 11:15 HSZ 04

Three-dimensional distribution of protected ferroelectric vortices in multiferroic hexagonal $YMnO_3$ — Tobias Jungk[1], •Martin Lilienblum[2], Ákos Hoffmann[1], Manfred Fiebig[2], and Elisabeth Soergel[1] — [1]PI, Universität Bonn, Wegelerstraße 8, 53115 Bonn, Germany — [2]HISKP, Universität Bonn, Nussallee 14-16, 53115 Bonn, Germany

Multiferrroics are a rich source for "unusual" forms of ferroelectric order. The spontaneous polarizations is induced by magnetism, charge order, geometric effects, etc., and may lead to novel domain states and functionalities. Here we show by piezoresponse force microscopy that ferroelectric domains in hexagonal multiferroic $YMnO_3$ form vortex-like structures around the direction of polarization. Although one would intuitively associate the sixfold character of the domain vortices to the uniaxial hexagonal structure, sixfold vortices are also present perpendicular to the direction of the spontaneous polarization. We will explain the intriguing topology on the basis of a simple geometric model. In addition, we will show how individual domain vortices are affected by application of an electric field applied along the polarization axis.

DF 8.4 Tue 11:30 HSZ 04

Poling of ferrotoroidic domains in $LiCoPO_4$ with toroidal fields — •Anne S. Zimmermann[1], Jean-Pierre Rivera[2], Hans Schmid[2], and Manfred Fiebig[1] — [1]HISKP, University of Bonn, Germany — [2]Department of Inorganic, Analytical and Applied Chemistry, University of Geneva, Switzerland

Ferrotoroidicity denotes a fourth, space- and time-asymmetric form of ferroic order with a spontaneous uniform alignment of magnetic vortices. Space and time asymmetry also relates ferrotoroidic materials to multiferroics and magnetoelectrics. After ferrotoroidic domains have been observed in $LiCoPO_4$ by second harmonic generation (SHG) experiments [1] controlled manipulation of these ferrotoroidic domains is the next step in demonstrating the ferroic nature of the toroidal state. This can be achieved by a toroidal field, i.e., a field behaving asymmetric under space inversion and time reversal, which can be realized by crossed electric and magnetic fields.

Here we report on the behaviour of ferrotoroidic domains in applied toroidal fields. The ferrotoroidic domain structure in various field experiments was investigated by phase-sensitive SHG. We demonstrate that it is possible to orient and switch the ferrotoroidic domains with an appropriate toroidal field. Furthermore the critical field strengths required to orient the ferrotoroidic domains and the relation of ferrotoroidic poling with magnetoelectric annealing are discussed. - Work supported by the SFB 608.

[1] B. B. Van Aken et. al., Nature 449, 702 (2007)

DF 8.5 Tue 11:45 HSZ 04

Time resolved measurements of the multiferroic switching in MnWO4 — •Max Baum[1], Thomas Finger[1], Jeannis Leist[2], Karin Schmalzl[3], Louis-Pierre Regnault[4], Petra Becker[5], Ladislav Bohatý[5], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Physikalische Chemie, Georg-August-Universität Göttingen — [3]Jülich Centre for Neutron Science (JCNS) at ILL, Grenoble — [4]Institut Nanosciences et Cryogénie, CEA-Grenoble — [5]Institut für Kristallographie, Universität zu Köln

Multiferroic materials or compounds with a strong magnetoelectric effect posses a large application potential in data storage techniques. Quite recently, systems with a peculiar spiral magnetic order were shown to directly induce a spontaneous electric polarisation and to exhibit giant magnetoelectric and magnetocapacitance effects, among them MnWO4. Neutron scattering with spherical polarisation analysis gives direct access to the chiral component of the magnetic structure which is directly linked to the electric polarisation and thus may be tunable by an electric field. In MnWO4 it is possible to drive multiferroic hysteresis loops at constant temperature as a function of the electric field. We broadened our investigations in this topic and present time resolved measurements of magnetoelectric switching. We applied stroboscopic techniques in order to investigate how fast the chiral component of the magnetic structure adapts to an instantaneously switched electric field. The time scale of the response is remarkable slow, in the range of 3 - 20 ms.

DF 8.6 Tue 12:00 HSZ 04

Time resolved reversal of spin-spiral domains by an electric field in multiferroic $MnWO_4$ — •Philip Thielen[1], Tim Hoffmann[1], Petra Becker[2], Ladislav Bohatý[2], and Manfred Fiebig[1] — [1]University Bonn, HISKP, Germany — [2]Institut für Kristallographie, Universität zu Köln

The interaction of magnetic and ferroelectric order is intrinsically strong in spin-spiral multiferroics. Here the complex magnetic long range order breaks inversion symmetry and induces a spontaneous electric polarization. The interaction allows for switching of the magnetization by means of an applied electric field and is thus of great interest for possible applications. So far there exists little information on the time scale and dynamics of the actual switching process. Here we report time resolved measurements of the reversal of spin-spiral domains in multiferroic $MnWO_4$ by optical second harmonic generation. Magnetic single-domain states are created by the application of an electric field. By reversing its polarity, a reversal of the magnetic domain state occurs. The time scale of the dynamic switching process is found to be in the ms region. Images of the domain-reversal process are obtained. The dynamic domain pattern differs substantially from that of quasi-statically switched multi domain structures.