

## MA 20: Multiferroics and Magnetoelectric coupling I (joint session MA/KFM)

Time: Tuesday 14:00–15:45

Location: H37

## Invited Talk

MA 20.1 Tue 14:00 H37

**Magnetoelectric Inversion of Domain Patterns** — ●NAËMI LEO<sup>1,2,3</sup>, VERA CAROLUS<sup>4</sup>, JONATHAN WHITE<sup>3</sup>, MICHEL KENZELMANN<sup>3</sup>, MATTHIAS HUDL<sup>5</sup>, PIERRE TOLEDANO<sup>6</sup>, TAKASHI HONDA<sup>7</sup>, TSUYOSHI KIMURA<sup>8</sup>, SERGEY IVANOV<sup>9</sup>, MATTHIAS WEIL<sup>10</sup>, THOMAS LOTTERMOSER<sup>2</sup>, DENNIS MEIER<sup>11</sup>, and MANFRED FIEBIG<sup>2</sup> — <sup>1</sup>CIC nanoGUNE, Spain — <sup>2</sup>ETH Zürich, Switzerland — <sup>3</sup>Paul Scherrer Institute, Switzerland — <sup>4</sup>Bonn University, Germany — <sup>5</sup>Stockholm University, Sweden — <sup>6</sup>Université de Picardie, France — <sup>7</sup>High Energy Accelerator Research Organization (KEK), Japan — <sup>8</sup>University of Tokyo, Japan — <sup>9</sup>Karpov Institute of Physical Chemistry, Russia — <sup>10</sup>TU Wien, Austria — <sup>11</sup>Norwegian University of Science and Technology, Norway

The global inversion of an inhomogeneous distribution of ferromagnetic or ferroelectric domains within a material is surprisingly difficult: Field poling creates a single-domain state, and piece-by-piece inversion using a scanning tip is impractical. Here we report inversion of entire domain patterns in the magnetoelectric material  $\text{Co}_3\text{TeO}_6$  and the multiferroic material  $\text{Mn}_2\text{GeO}_4$ . In these materials, an applied magnetic field reverses the magnetization or polarization, respectively, of each domain, but leaves the overall domain pattern intact. This effect originates from a trilinear coupling term containing a "hidden" order parameter which retains the relative orientation of the field-driven and the observed order parameters. Such behaviour might also occur in other complex materials where coexisting order parameters are available for combination.

MA 20.2 Tue 14:30 H37

**Dielectric response of a vector-chiral magnetic ordering** — ●DAVID RIVAS GONGORA<sup>1</sup>, MARTINA DRAGIČEVIĆ<sup>1</sup>, ŽELJKO RAPLJENIČIĆ<sup>1</sup>, MIRTA HERAK<sup>1</sup>, TOMISLAV IVEK<sup>1</sup>, MATEJ PREGELJ<sup>2</sup>, ANDREJ ZORKO<sup>2</sup>, HELMUTH BERGER<sup>3</sup>, and DENIS ARČON<sup>2</sup> — <sup>1</sup>Institute of Physics, Bijenička cesta 46, HR-10000 Zagreb, Croatia — <sup>2</sup>Jožef Stefan Institute, Jamova c. 39, 1000 Ljubljana, Slovenia — <sup>3</sup>Ecole polytechnique federale de Lausanne, CH-1015 Lausanne, Switzerland

$\beta$ -TeVO<sub>4</sub> is a zig-zag spin-1/2 quasi-one-dimensional system with a rich low-temperature phase diagram. Its vanadium spins interact through a nearest ferromagnetic (V-O-V) and next-nearest antiferromagnetic (V-O-Te-O-V) superexchange. The resulting frustration assisted by quantum fluctuations gives rise to three magnetic phase transitions [1]: paramagnetic to incommensurate spin density wave at  $T_{N1}=4.65$  K, followed by the so-called stripe phase under  $T_{N2}=3.28$  K, and lastly at  $T_{N3}=2.28$  K the system enters the vector-chiral ground state [2]. Interestingly, the complex magnetic landscape makes  $\beta$ -TeVO<sub>4</sub> an ideal candidate for non-conventional magnetoelectric phases due to a symmetry which does not forbid the formation of electric dipoles [2,3]. We present the dynamic dielectric response of  $\beta$ -TeVO<sub>4</sub> single crystal samples in the presence of a magnetic field and discuss it in the context of low-temperature magnetic ordering as a potentially multiferroic phase.

[1] Y. Savina et al. Phys. Rev. B 84, 104447 (2011). [2] M. Pregelj et al. Nature Communications 6 (2015), 10.1038/ncomms8255. [3] K. F. Wang et al. Adv. Phys 58, 321-448 (2009).

MA 20.3 Tue 14:45 H37

**Magnetoelectric Red-Ox switching of magnetism in iron oxide/iron nanostructures** — ●JONAS ZEHNER<sup>1,2</sup>, IVAN SOLDATOV<sup>1</sup>, RUDOLF SCHÄFER<sup>1</sup>, SEBASTIAN FÄHLER<sup>1</sup>, KORNELIUS NIELSCH<sup>1,2</sup>, and KARIN LEISTNER<sup>1,2</sup> — <sup>1</sup>IFW Dresden — <sup>2</sup>TU Dresden - Institute of Material Science

Low power voltage-control of magnetism in metals can be achieved by electrical gating of magnetic nanostructures. Recent approaches focus on ion displacement and electrochemical reactions in oxide/metal films[1,2]. All solid state architectures suffer from a low ion mobility at room temperature (RT) and focus on ultrathin films so far[3]. Utilizing liquid electrolytes allows us to overcome these limitations and achieve large voltage induced changes of magnetization and anisotropy within several nanometer thick oxide/metal heterostructures[4]. In this case, typical alkaline battery electrolytes are used and merely 1V is applied to induce electrochemical RedOx processes in nanostructured FeOx/Fe films[4,5]. For FeOx/Fe nanoislands, ON/OFF switching of magnetization has been probed by two independent integral methods: in situ

AHE and in situ FMR. A novel in situ Kerr set up has been developed, which allows us to observe also local changes of the magnetic microstructure during the RedOx operations. We find, for the first time, significant voltage-induced changes of the domain size in continuous FeOx/Fe thin films upon RedOx reactions. [1]Song et al., Prog. Mater. Sci. 87, 33,2017, [2]Leistner et al., PRB 87, 224411,2013, [3]Bauer et al., Nat. Mater. 14, 174,2015, [4]Dusчек et al. APL Mater.4, 32301,2016 [5]Dusчек et al., J. Mater. Chem. C 6, 8411,2018

MA 20.4 Tue 15:00 H37

**Switchable one-way transparency via coupled magnetic and electric resonances** — ●DAVID SZALLER<sup>1</sup>, ARTEM KUZ'MENKO<sup>2</sup>, ALEXANDER A. MUKHIN<sup>2</sup>, ALEXEY SHUVAEV<sup>1</sup>, URMAS NAGEL<sup>3</sup>, TOOMAS RÖÖM<sup>3</sup>, and ANDREI PIMENOV<sup>1</sup> — <sup>1</sup>Institute of Solid State Physics, TU Wien, Vienna, Austria — <sup>2</sup>Prokhorov General Physics Institute, Russian Academy of Sciences, Moscow, Russia — <sup>3</sup>National Institute of Chemical Physics and Biophysics, Tallinn, Estonia

The strong anisotropy in the absorption of counter-propagating light beams approaching the limit of one-way transparency[1] became an intensively studied topic of simultaneously magnetic and polar (i.e. multiferroic) crystals, motivated by both the fundamentals of non-reciprocity and the possible information-technology applications. However, due to the limited understanding of the phenomenon the design of one-way transparent devices with specified optical spectrum is still an open task. On the basis of symmetry analysis and statistical physical considerations[2], it is possible to construct a minimal model of one-way transparency consisting of a pair of coupled magnetic and electric resonances. This model can be realized in certain multiferroic crystals and also in metamaterial structures, opening the path to custom-designed, electrically[3] or magnetically[1] switchable optical response.

[1] I. Kézsmárki, D. Szaller et al., Nat. Commun. 5, 3203 (2014)  
[2] D. Szaller et al., PRB 87, 014421 (2013) and PRB 89, 184419 (2014)  
[3] A. M. Kuz'menko, D. Szaller et al., PRL 120, 027203 (2018)

MA 20.5 Tue 15:15 H37

**Multiferroic domain inversion in NaFeGe<sub>2</sub>O<sub>6</sub>** — ●SEBASTIAN BIESENKAMP<sup>1</sup>, DMITRY GORKOV<sup>1</sup>, TOBIAS FRÖHLICH<sup>1</sup>, JONAS STEIN<sup>1</sup>, KARIN SCHMALZL<sup>2</sup>, WOLFGANG SCHMIDT<sup>2</sup>, YVAN SIDIS<sup>3</sup>, and MARKUS BRADEN<sup>1</sup> — <sup>1</sup>Institute of Physics II, University of Cologne — <sup>2</sup>JCNS at ILL, Grenoble — <sup>3</sup>Laboratoire Léon Brillouin, CEA-CNRS, CEA/Saclay

Multiferroic materials attracted a considerable interest during the last decade, as the electric control of chiral magnetism implies a promising potential of applicability in the field of data storage devices or sensors. Fundamentally for all kind of applications is the knowledge of the relaxation times of multiferroic domain inversion, when switching applied external electric fields. Here we report time-resolved neutron scattering studies of the relaxations times in the multiferroic pyroxene NaFeGe<sub>2</sub>O<sub>6</sub>. They can be followed over a broad timescale, ranging from microseconds to several minutes and we found that the temperature and electric field dependence of the rise-times can be well described by a simple activation and Merz's law respectively.

MA 20.6 Tue 15:30 H37

**Temperature- and pressure-dependent optical measurements on the photo-response in multiferroic BiFeO<sub>3</sub>** — ●FABIAN MEGGLE<sup>1</sup>, JIHAAN EBAD-ALLAH<sup>1,2</sup>, MICHEL VIRET<sup>3</sup>, JENS KREISEL<sup>4,5</sup>, and CHRISTINE KUNTSCHER<sup>1</sup> — <sup>1</sup>Experimentalphysik II, Universität Augsburg, 86159 Augsburg, Germany — <sup>2</sup>Department of Physics, Tanta University, 31527 Tanta, Egypt — <sup>3</sup>Service de Physique de l'État Condensé, SPEC, CEA Saclay, CNRS, Université Paris-Saclay, 91191 Gif sur Yvette, France — <sup>4</sup>Physics and Materials Science Research Unit, University of Luxembourg, 4422 Belvaux, Luxembourg — <sup>5</sup>Department Materials Research and Technology, Luxembourg Institute of Science and Technology, 41 Rue du Brill, 4422 Belvaux, Luxembourg

BiFeO<sub>3</sub> exhibits three absorption features in the optical transmission spectrum between 1.0 and 2.2 eV during laser illumination.<sup>1</sup> These features were ascribed to excitons, which are proposed to be relevant for the ultrafast photostriction effect in BiFeO<sub>3</sub>.<sup>2</sup> We studied the impact

of low temperature and high pressure on the photo-induced features by using optical spectroscopy. Our temperature-dependent findings suppose a possible coupling between absorption features and lattice vibrations, whereas the spin degree of freedom might be also involved. The pressure-dependent measurements show a vanishing of the absorp-

tion features above 3.5 GPa, where BiFeO<sub>3</sub> is reported to undergo a phase transition from polar to a non-ferroelectric phase.<sup>3</sup> <sup>1</sup>Burkert et al., Appl. Phys. Lett. **109**, 182903 (2016); <sup>2</sup>Schick et al., Phys. Rev. Lett. **112**, 97602 (2014); <sup>3</sup>Belik et al., Chem. Mater. **21**, 3400 (2009)