MI 2: Symposium Novel Functionality and Topology-Driven Phenomena in Ferroics and Correlated Electron Systems (DF with MA, KR, MI, TT and DS)

Time: Monday 15:00–18:00 Location: HSZ 02

Invited Talk MI 2.1 Mon 15:00 HSZ 02

Ferroelectric domain walls: from conductors to insulators and back again — •Petro Maksymovych — Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, Oak Ridge, USA

The root cause of uncertainty around conducting ferroelectric domain walls (DWs) is the contact problem, which may be intrinsic to the polarization topology and may not be resolved by doping ferroelectric films. We revealed how contact effects are responsible for apparent DW conductance in ultrathin BiFeO3, wherein the DW electrostatically gates the interface, but is not itself a conductor. At the same time, we explored AC conductance of DWs to eliminate contact effects. DWs in both BiFeO3 and Pb(Zr0.2Ti0.8)O3 revealed robust conductivity at 3 GHz with remarkably large values of 2-6 S/m. Using the Ginzburg-Landau-Devonshire model for ferroelectric semiconductor, the effect is traced to local charge of nominally straight DWs due to defect-induced roughening and/or an intrinsic flexoelectric effect. Microwave regime opens new opportunities for device integration and carrier-density and dielectric effects at DWs.

Support provided by U.S. Department of Energy, BES, Materials Science and Technology Division. Microscopy experiments performed at the Center for Nanophase Materials Sciences, a DOE Office of Science User Facility.

[1] R. K. Vasudevan, et al., and P. Maksymovych, submitted (2016)
[2] A. Tselev, P. Yu, Y. Cao, L. R. Dedon, L. W. Martin, S. V. Kalinin, and P. Maksymovych, Nat. Comms., 7 (2016) 11630.

Invited Talk MI 2.2 Mon 15:30 HSZ 02

Zoology of skyrmions and the role of magnetic anisotropy in the stability of skyrmions — •Istvan Kezsmarki[1], Sandor Bordacs[1], Jonathan White[2], Vladimir Tsurkan[3], Alois Loidl[3], Peter Milde[4], Hiroyuki Nakamura[5], and Andrey Leonov[6] — [1]Budapest University of Technology and Economics, Budapest, Hungary — [2]Paul Scherrer Institute, Villingen, Switzerland — [3]University of Augsburg, Augsburg, Germany — [4]Technical University of Dresden, Dresden, Germany — [5]University of Kyoto, Kyoto, Japan — [6]University of Hiroshima, Hiroshima, Japan

Skyrmions are nanometric magnetic objects with high stability owing to their topological structures. The internal spin pattern of skyrmions depends on the crystal symmetry of the host materials. While we know many chiral crystals hosting Bloch-type skyrmions, Néel-type skyrmions have only recently observed in polar compounds. On experimental basis, I am going to compare the main characteristics of the two types of skyrmions and discuss the effect of magnetic anisotropy on the thermal stability range of the corresponding Bloch- and Néel-type skyrmion lattices.

Invited Talk MI 2.3 Mon 16:00 HSZ 02

Magnetic imaging of topological phenomena in ferroic materials — •Weida Wu — Department of Physics and Astronomy, Rutgers University, Piscataway, NJ, 08854 USA

Topology is a pervasive concept in condensed matter physics. Topological phenomena such as vortices, Skyrmions and chiral edge states are mesoscopic textures that are crucial for the physical properties and functionalities. Thus, it is imperative to directly visualize these mesoscopic phenomena. In this talk, I will present our recent discovery of alternating uncompensated magnetic moments at Z6 vortex domain walls in hexagonal manganites, which demonstrates the coupling between ferroelectric and antiferromagnetic orders. Furthermore, magnetoelectric response of the vortex domains were directly visualized by Magnetoelectric Force Microscopy (MeFM), a combination of MFM with in-situ modulating high electric fields. Our MeFM results reveal a giant enhancement of magnetoelectric response of a lattice mediated magnetoelectric effect near a spin-reorientation critical point.

This work is supported by US DOE under grant DE-SC0008147.

30 min. break

Invited Talk MI 2.4 Mon 17:00 HSZ 02

Topological skyrmion textures in chiral magnets — •Markus Garst — Institut für Theoretische Physik, Technische Universität Dresden, Zellescher Weg 17, 01062 Dresden, Germany

A magnetization that spatially varies within a plane can be characterized by a topological skyrmion number specifying how often the magnetization vector covers the unit sphere. Magnetic skyrmion textures with such a non-trivial winding number are endowed with additional functionality as they efficiently couple to magnon- and itinerant spin currents allowing for novel spintronic applications. Such textures arise, in particular, in chiral magnets where the Dzyaloshinskii-Moriya interaction favours a spatially modulated magnetization. This stabilizes magnetic solitons that carry an integer skyrmion charge as well as regular arrangements thereof, i.e., skyrmion crystals. We demonstrate that defects of helimagnetic order can carry half-integer skyrmion numbers. In analogy to cholesteric liquid crystals, such defects can be interpreted as disclinations and dislocations that are instrumental for the magnetic relaxation process in these systems. We also show that an array of such defects might arise in topological domain walls of helimagnetic order permitting an efficient manipulation by spin currents.

Invited Talk MI 2.5 Mon 17:30 HSZ 02

Learning through ferroelectric domain dynamics in solidstate synapses — Sören Boyn[1], Gwendal Lecerf[2], Stéphane Fusil[1], Sylvain Saïghi[2], Agnès Barthélémy[1], Julie Grollier[1], Vincent Garcia[1], and •Manuel Bibes[1] — [1]Unité Mixte de Physique CNRS/Thales, Palaiseau FRANCE — [2]IMS Laboratory, U. Bordeaux FRANCE

In the brain, learning is achieved through the ability of synapses to reconfigure the strength by which they connect two neurons. Artificial hardware with performances emulating those of biological systems require electronic nanosynapses endowed with such plasticity. Promising solid-state synapses are memristors, simple two-terminal nanodevices that can be finely tuned by voltage pulses. Their conductance evolves according to a learning rule called spike-timing-dependent plasticity, conjectured to underlie unsupervised learning in our brains. We will report on purely electronic ferroelectric synapses and show that spike timing-dependent plasticity can be harnessed and tuned from intrinsically inhomogeneous ferroelectric polarisation switching. Through combined scanning probe imaging and electrical transport experiments, we demonstrate that conductance variations in such BiFeO3-based ferroelectric memristors can be accurately controlled and modelled by the nucleation-dominated electric-feld switching of domains with different polarisations. Our results show that ferroelectric nanosynapses are able to learn in a reliable and predictable way, opening the way towards unsupervised learning in spiking neural networks.