TT 7: Micro- and Nanostructured Materials (joint session MA/TT)

Time: Monday 9:30–11:15 Location: HSZ 403

TT 7.1 Mon 9:30 HSZ 403

Magnetization properties of individual 3D Fe-Co Nanostructures — •Mohanad Al Mamoori[1,2], Fabrizio Porrati[1], Michael Huth[1], Christian Schröder[3], and Jens Müller[1] — [1]Institute of Physics, Goethe University Frankfurt, Germany — [2]Institute of Materials Science, Technical University of Darmstadt, Germany — [3]Institute for Applied Materials Research, Bielefeld University of Applied Sciences, Germany

The transition from 2D to 3D nanomagnetism may bring with it the emergence of novel physical effects and enable future magnetic memory and sensing applications. In [1,2], we have employed focused electron beam induced deposition (FEBID) to grow 3D nanomagnets as nanocubes and nano-trees directly onto a micro-Hall sensor acting both as substrate and high-resolution detection device of small magnetic stray fields. We find that the magnetisation reversal propagates by multi-vortex switching scenarios. In this presentation, firstly, we report systematic measurements of magnetic stray fields of newly grown Fe-Co tetrahedral structures as building blocks of diamond lattices as a function of temperature and magnetic field applied at different angles. Secondly, in order to gain further insights in the hysteresis loops, (irreversible) magnetic interaction effects and coercivity distributions, first-order-reversal curves (FORC) of these 3D nanomagnets supported will be shown. Finally, an outlook to the future design of such structures towards the realization of 3D artificial spin ice architectures will be given. [1] L.Keller et al., *Sci. Rep.* **8** , 6160 (2018). [2] M. Al Mamoori et al., *Materials* **11**, 289 (2018).

TT 7.2 Mon 9:45 HSZ 403

Magnetization reversal in round and square nanodots — •Andrea Ehrmann[1] and Tomasz Blachowicz[2] — [1]Bielefeld University of Applied Sciences, Faculty of Engineering and Mathematics, Bielefeld, Germany — [2]Silesian University of Technology, Institute of Physics - Center for Science and Education, Gliwice, Poland

Ferromagnetic nanodots in different shapes can be applied in data storage, spintronics, neuromorphic computing, etc. Especially the possibility to create vortex states is of high technological interest since these states have significantly reduced stray fields and correspondingly less interaction with neighboring nanodots. Whether a vortex state occurs in the absence of an external magnetic field, depends on the dimensions of the nanodots and, in case of not round nanoparticles, on the shape, since the shape anisotropy significantly influences magnetization reversal processes.

Here we give an overview of magnetization reversal processes in square [1] and round nanodots [2], often including a single-vortex state, while in some cases two, three or even more vortex-antivortex pairs can be found. We also show the stability of single vortex ground states, i.e. the states usually suggested for data storage, which depends strongly on the dot geometry.

[1] A. Ehrmann, T. Blachowicz, Hyperfine Interactions 239, 8 (2018)
[2] A. Ehrmann, T. Blachowicz, J. Magn. Magn Mater. 475, 727-733 (2019)

TT 7.3 Mon 10:00 HSZ 403

Experimentally observable curvature-induced effects in parabolic nanostripes — •Oleksii M. Volkov[1], Attila Kákay[1], Florian Kronast[2], Ingolf Mönch[1], Mohamad-Assaad Mawass[2], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum-Dresden-Rossendorf, Dresden, Germany — [2]Helmholtz-Zentrum Berlin für Materialen und Energie, Berlin, Germany

Dzyaloshinskii-Moriya interaction (DMI) is a key aspect in magnetism that can lead to the appearance of chiral effects, such as the topological Hall effect [1], or to the formation of chiral noncollinear magnetic textures, as skyrmions or chiral domain walls [1]. Curvature effects in magnetism offer means to create chiral interactions like DMI based on the geometry of thin films [2]. This extrinsic tailoring of the DMI (strength and spatial orientation) is in stark contrast to conventional approaches, where chiral interactions are tuned relying on extensive material screening. Very recently, we provide the very first experimental confirmation of the existence of curvature-induced DMI in parabola-shaped Permalloy nanostripes [3,4]. The magnitude of the effect can be tuned by the parabola's curvature and width, while its value is comparable with those experimentally reported for asymmetric Co sandwiches.

[1] N. Nagaosa and Y. Tokura, Nat. Nanotechnol. **8**, 899 (2013).
[2] Y. Gaididei et al., PRL **112**, 257203 (2014).
[3] O. Volkov et al., PRL **123**, 077201 (2019).
[4] O. Volkov et al., PSS-RRL **13**, 1800309 (2019).

TT 7.4 Mon 10:15 HSZ 403

Giant Photovoltaic Effect in Magnetic Materials — •Oles Matsyshyn and Inti Sodemann — MPI PKS, Dresden, Germany

We investigate a rectification process present in materials that break both inversion and time reversal symmetries. At second order in electric fields, this effect is inverseley proportional to the relaxation rate, and, therefore, the rectified current would be infinity in a "naive" ideal clean and zero temperature limit. Employing Floquet theory, we show, however, that there is a non-perturbative correction in the electric field strength that regularises this divergence, but, which ultimately leads to a giant photo-current generation. Therefore, this effect offers a promising alternative paradigm for solar cell technologies.

TT 7.5 Mon 10:30 HSZ 403

Microscopic origin of improved magnetic fluid hyperthermia performance of CFO-Pd heterodimers: Element-specific investigations of structural, electronic, and magnetic characteristics — •S. Fatemeh Shams[1], Detlef Schmitz[2], Alevtina Smekhova[2], Eugen Weschke[2], Kai Chen[2], Chen Luo[2], Amir. H. Tavabi[3], Sussane Pettinger[4], Konrad Siemensmeyer[2], Gil Westmeyer[4], Rafal E. Dunin-Borkowski[3], Florin Radu[2], and Carolin Schmitz-Antoniak[1] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, 14109 Berlin, Germany — [3]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany — [4]Institute of Biological and Medical Imaging (IBMI), Helmholtz Zentrum München, 85764 Neuherberg, Germany

Cobalt ferrite nanoparticles were synthesized and randomly decorated with approximately 2 wt.% of Pd particles. After careful structural and compositional characterization, X-ray absorption spectroscopy was used to investigate their element-specific magnetic properties. A significant increase in the effective spin and orbital magnetic moments of both the Fe and the Co ions was found upon decoration with Pd, leading to an increase in total magnetic moment per formula unit by 60% for the larger nanoparticles and by 200% for the smaller ones at 300 K. XMCD measurements show that the magnetic field dependence of the Co moment is much steeper at lower magnetic fields, leading to an enhanced maximum heating power in hyperthermia experiments.

TT 7.6 Mon 10:45 HSZ 403

Strain induced orientation of hematite nanospindles studied via Mössbauer spectroscopy — •Damian Günzing[1], Julian Seifert[2], Samira Webers[1], Joachim Landers[1], Annette M. Schmidt[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen — [2]Department of Chemistry, Institute of Physical Chemistry, University of Cologne

Magnetic nanoparticles embedded in different matrices are a promising hybrid material class with the opportunity of tayloring the magneto-elastic properties. For an efficiently working hybrid material, it is mandatory to understand the particle matrix interaction on the nanoscale. In this work spatial particle ordering of anisotropic hematite nanospindels [1] is induced via applied strain to an elastomer matrix with incorporated particles. To study the ordering process the focus lies on the element specific Mössbauer spectroscopy with and without an applied magnetic field. With this technique we obtain information about the spin orientation and Brownian diffusion simultaneously from the measured spectra. The distributions in spin orientation are further compared to Monte-Carlo simulations calculating the degree of ordering. As a complementary method, small angle x-ray scattering measurements are performed on the sample systems to determine the ordering parameter from the spatial particle distribution. This work is financially supported by the DFG priority program SPP1681 (WE2623/7-3).

[1] J. Landers et al., J. Phys. Chem. C 119, 20642-20648 (2015)

TT 7.7 Mon 11:00 HSZ 403

Cellulose nanocomposite with $SrFe_{12}O_{19}$ nanoparticles as a novel magnetic nanopaper source — •Andrei Chumakov[1], Calvin Brett[1,2], Artem Eliseev[3], Evgeny Anokhin[3], Lev Trusov[3], Lewis Akinsinde[4], Marc Gensch[1,5], Dirk Menzel[6], Matthias Schwartzkopf[1], Micheal Rübhausen[4], and Stephan Roth[1,2] — [1]DESY, Hamburg, Germany — [2]KTH Royal Institute of Technology, Stockholm, Sweden — [3]MSU, Moscow, Russia — [4]CFEL, Universität Hamburg, Hamburg, Germany — [5]TUM, Garching, Germany — [6]TU Braunschweig, Braunschweig, Germany

The combination of biocompatible cellulose nanofibrils (CNF) with magnetic nanoparticles provides a promising magnetic composite material for flexible and electromechanical devices. Superparamagnetic ferrite nanoparticles are used as a magnetic material for such composites. We combined CNF with a novel type of stable magnetic colloids based on disc-like (diameter 40 nm, thickness 5 nm) hard magnetic hexaferrite ($SrFe_{12}O_{19}$) particles, electrostatically stabilized in aqueous solution. Each particle carries a large permanent magnetic moment oriented perpendicularly to the plate surface (Ms = 50 emu/g, Hc = 4500 Oe). As a result of the interaction of positively charged magnetic particles with a negatively charged surface of the CNF (1360 μmol/g), a thin film of the magnetic composite material was fabricated by spray deposition. The structure was studied by imaging, X-ray scattering and the magnetic techniques of such a composite showed a uniform distribution of single hexaferrite nanoparticles in a cellulose matrix.