MA 19: Poster I

Nanoparticles / Nanostructured Magnetic Materials / Magnetic Shape Memory Alloys / Experimental Methods / Magnetic Materials / Bio- and Molecular Magnetism

Time: Tuesday 13:00–15:30 Location: P1

MA 19.1 Tue 13:00 P1

Magnetization of a nickel-based spin tube — •Michael Czopnik and Jürgen Schnack — University of Bielefeld

We study the ground state and the magnetization of a Heisenberg spin tube made of nickel spins $s = 1$, using Density Matrix Renormalization Group technique and exact diagonalization.

Special emphasis is put on unusual features of the magnetization curve, such as extended plateaus or jumps.

The relevance of these results to experiments is also discussed.

MA 19.2 Tue 13:00 P1

Investigation of spin systems with anisotropy using the Finite-Temperature Lanczos-Method — •Oliver Hanebaum and Jürgen Schnack — Universität Bielefeld, Germany

We calculate approximate partititon functions and magnetization as well as the effective magnetic moment of spin systems with Hilbert space dimension up to 10^{10}. The Hamiltonian contains a Heisenberg part, anisotropic exchange and local anisotropy as well as a g-tensor. Observables are obtained by the finite-temperature Lanczos-method.

MA 19.3 Tue 13:00 P1

[Cu_2^{II}(NGuaS)$_2$Cl$_2$]: Antiferromagnetic coupling and optical response, a broken symmetry DFT analysis — •Matthias Witte, Uwe Gerstmann, Eva Rauls, and Wolf Gero Schmidt — University Paderborn, Germany

Copper enzymes are of utter importance for biochemical processes in nature. Their capability of hydroxylating phenols to catechols, for example, is essential for the tyrosinase process. Hence understanding their electronic structure and rationalizing their spectroscopic fingerprints are primary goals for theoretical chemistry. However the computation of their structural and electronic properties turns out to be quite challenging and typically smaller model systems are investigated showing similar functionalities. Gerald Henkel and co-workers succeeded in the previously unknown chloride-induced disulfide thiolate interconversion, leading from the copper(I) disulfide complex cation [Cu_2^{I}(NGuaS)$_2$]$^{2+}$ to the electrically neutral copper(II) thiolate species [Cu_2^{II}(NGuaS)$_2$Cl$_2$]. [1] We analyse the electronic groundstate which is antiferromagnetically coupled by the use of density functional theory. We employ the B3LYP hybrid functional and an atom-centered cc-pVDZ basis set. The optical spectra are calculated using the TDDFT approach. In order to rationalize the antiferromagnetic coupled groundstate we analyze the electronic structure in detail and trace it to a more favorable Coulomb interaction.

[1] A. Neuba et al., A Halide-Induced Copper(I) Disulfide/Copper(II) Thiolate Interconversion, Angewandte Chemie International Edition, 51, 1714 (2012)

MA 19.4 Tue 13:00 P1

On the height of the magnetic anisotropy barrier — •Claudia Martin and Jens Kortus — TU Bergakademie Freiberg, Fakultät für Chemie und Physik

We will present a systematic study of the influence of the magnetic ground state S on the magnetic anisotropy D for a family of Mn_6 compounds. We have been able to show that the system can either minimize S or D. Furthermore, our results indicate that the barrier $U=S^2|D|$ is nearly constant for the investigated range of possible ground states S. Interestingly the highest barrier is observed for the lowest ground states S while the high spin ground state yields the lowest barrier, which we will also comment on.

MA 19.5 Tue 13:00 P1

High-frequency electron paramagnetic resonance studies on heterometal-organic complexes — Changhyun Koo[1], Jaena Park[1], Sebastian Schmidt[2], Dieter W. Heermann[3], Vladislav Kataev[4], Annie K. Powell[2,5], and •Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany — [2]Institute of Inorganic Chemistry, Karlsruhe Institute of Technology, Karlsruhe, Germany — [3]Institute for Theoretical Physics, University of Heidelberg, Heidelberg, Germany — [4]Leibniz Institute for Solid State and Materials Research IFW Dresden, Dresden, Germany — [5]Institute of Nanotechnology, Karlsruhe Institute of Technology, Karlsruhe, Germany

High-frequency electron paramagnetic resonance (HF-EPR) is a powerful tool to investigate in detail spin dynamics and magnetic properties such as g-factor, spin states, anisotropy, and exchange interaction of various materials. The tunable HF-EPR set-up established in Heidelberg covers the frequency range from 8 GHz to 1 THz and allows magnetic fields up to 18 T. Studies on various heterometallic complexes consisting of transition metal and/or lanthanide ions will be presented. One example are 3d-4f heteronuclear clusters, Fe_4Ln_2-comlexes Ln = Tb, Dy, Ho, Y, and Gd. HF-ESR data analyzed in terms of the Ising-spin concept provide estimates of the magnetic coupling between $4f$- and $3d$-ions.

MA 19.6 Tue 13:00 P1

Structural and Magnetic Properties of Magnetite Thin Films grown by Low Oxygen Metalorganic Aerosol Deposition — •Victor Pfahl, Sebastian Hühn, Markus Jungbauer, and Vasily Moshnyaga — I Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

Magnetite (Fe_3O_4) is a ferrimagnet with an inverse spinel structure which has drawn attention in the field of spin electronics due to its half-metallic properties with 100% spin-polarization and its high T_C of 858K [1][2]. We have grown Fe_3O_4 thin-films on $SrTiO_3$, MgO and Al_2O_3 substrates with Low-Oxygen Metalorganic Aerosol Deposition (LO-MAD). Structural properties were characterized by XRR, XRD, STM, and Raman spectroscopy. Resistivity and magnetization were measured with PPMS, MPMS and MOKE. As we vary the oxygen ambient pressure, we are also able to grow different members of the Fe-O phase diagram like $\gamma - Fe_2O_3$, $\alpha - Fe_2O_3$ and mixed phases. STM indicates epitaxial 2D island growth of the magnetite thin films with film thicknesses of 30nm to 50nm, island heights of one atomic layer, and RMS < 0.7nm. The saturation magnetization at 10K $M_{sat} = (29.8 \pm 3.8)\mu_B$ is close to the theoretical value of $M_{sat} = 32\mu_B$. Financial support from EU FP 7, IFOX (interfacing oxides) project is acknowledged.

[1] Microstructure and magnetic properties of strained Fe3O4 films Chen, Y. Z. et al., Journal of Applied Physics, 103, 07D703 (2008).

[2] New Class of Materials: Half-Metallic Ferromagnets de Groot, R. A. et al. Phys. Rev. Lett. 50, 2024-2027 (1983)

MA 19.7 Tue 13:00 P1

Recent Advances of Metalorganic Aerosol Deposition — •Markus Jungbauer[1], Sebastian Hühn[1], Markus Michelmann[1], Felix Massel[1], Victor Pfahl[1], Camillo Ballani[1], Danny Schwarzbach[1], Ricardo Egoavil[2], Jo Verbeeck[2], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Georg-August-Universität, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Electron Microscopy for Materials Science (EMAT) , Groenenborglaan 171, 2020 Antwerp, Belgium

Metalorganic Aerosol Deposition (MAD) is a chemical-solution-based technique developed to grow oxide thin films at vacuum-free conditions. It has already been established that high quality films of different materials, like manganites, cobaltites, titanates, ruthenates, cuprates, ZnO, can be deposited by MAD. The recently installed in-situ ellipsometry enables to monitor important growth parameters (substrate temperature, film thickness) as well as to characterize the growth mode. Moreover, a valuable information on the electronic intermixing at the interfaces and roughening during the growth can be obtained. This is especially useful for MAD atomic layer epitaxy (ALE), which we applied to grow perovskites ABO_3 by alternating deposition of AO and BO_2 layers. A "layer-by-layer" (A-O/B-O2) growth of manganite films was achieved as well as the valence change of the Mn-ions during the growth was detected. The reduction of oxygen partial pressure allowed us to access new materials, like the high T_C double perovskites and magnetite (Fe_3O_4), which are unstable under ambient conditions. Financial support from EU FP 7, IFOX project is acknowledged.

MA 19.8 Tue 13:00 P1

Influence of the antiferromagnetic bulk on exchange bias in Ni/FeF_2 bilayer systems — •Henning Huckfeldt[1], Ali C. Basaran[2,3], Thomas Saerbeck[2], Jose de la Venta[2], Ivan K. Schuller[2], and Arno Ehresmann[1] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Department of Physics and Center for Advanced Nanoscience, University of California San Diego, La Jolla, CA 92093 USA — [3]Materials Science and Engineering,University of California San Diego, La Jolla, CA 92093 USA

Almost all theoretical descriptions of the exchange bias effect are based on the interaction between the ferro- and antiferromagnetic material at the interface while the bulk of the antiferromagnet is neglected.

We present a series of experiments highlighting the influence of the antiferromagnetic bulk in a Ni/FeF_2 bilayer system on exchange bias. By bombardment with 9 keV He^+ ions and changing penetration depths into the material system defects were created influencing the exchange bias effect. The results were confirmed by numerical simulations of the ion range and damage. Quantitative magnetic and structural characterizations were performed probing the effects of ion bombardment. It is shown that the antiferromagnetic bulk can not be neglected for a quantitative description of the exchange bias effect.

MA 19.9 Tue 13:00 P1

Directed magnetic particle transport above magnetic stripe-patterned exchange-bias layer systems due to dynamic magnetic potential energy landscape transformation — •Dennis Holzinger, Iris Koch, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Magnetic stripe patterned exchange-bias (EB) layer systems with tailored domain wall charges between the in-plane magnetized magnetic domains,[1] fabricated via ion bombardment induced magnetic patterning (IBMP), are used for the directed transport of micron-sized superparamagnetic core-shell particles due to the dynamic transformation of the particles magnetic potential energy landscape during the application of small external magnetic field pulses without changing the samples magnetic state. A theoretical model is introduced to quantitatively calculate the magnetic particle velocity as a result of the spatial changes in the magnetic potential energy landscape, where the actual particle-substrate distance is for the first time investigated both experimentally and theoretically. Since the magnetic potential energy landscape can be precisely adjusted via IBMP, this system seems to be promising for tailoring the particle velocity as a function of the intrinsic material properties of the EB system.

[1] D. Holzinger, N. Zingsem, I. Koch, A. Gaul, M. Fohler, C. Schmidt and A. Ehresmann, J. Appl. Phys. 114, 013908 (2013)

MA 19.10 Tue 13:00 P1

Magnetic Properties of Self-Assembled Fe_2O_3 Nanoparticles — •Alice Klapper[1], Sabrina Disch[2], Erik Wetterskog[3], Michael Agthe[3], Lennart Bergström[3], Stefan Mattauch[4], Oleg Petracic[1], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich, GERMANY — [2]Institut Laue-Langevin, F-38042 Grenoble Cedex 9, FRANCE — [3]Materials and Environmental Chemistry, Stockholm University, 10691 Stockholm, SWEDEN — [4]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at MLZ, Lichtenbergstr. 1, 85748 Garching, GERMANY

Today's requirements for data storage density grow continuously. Magnetic nanoparticles constitute a possible new recording material. Therefore, nanoparticle superlattices have moved into the focus of worldwide research activities. We follow an approach to investigate the magnetic ordering within mesocrystals of cubic shaped γ-Fe_2O_3 nanoparticles (NPs). The crystal structure of the superlattice has been obtained from GISAXS measurements. To have direct access to the magnetic inter-particle superspin-structure inside the supercrystals the usage of the GISANS technique with polarized neutrons is inevitable. We performed polarized GISANS measurements in various applied fields and obtained results, which are correlated to models of collective magnetic states inside mesocrystals.

MA 19.11 Tue 13:00 P1

Rapid thermoreversible formation of ordered monolayers of superparamagnetic beads interconnected by DNA bridges — •Marianne Bartke, Bernhard Eickenberg, Frank Wittbracht, and Andreas Hütten — Department of Physics, Thin Film and Physics of Nanostructures, University of Bielefeld, D-33615 Bielefeld, Germany

Superparamagnetic beads have numerous applications within microfluidic systems, where they can be used to serve as mobile substrates, bind, transport and separate analytes or as magnetic labels. Recently, the use of beads as self-assembling matter has attracted attention. Under the influence of a rotating homogeneous magnetic field, beads rapidly form ordered monolayers. In the absence of a magnetic field, the cluster structures rapidly disassemble. In this work, a method to prevent the decay of the monolayers in the absence of a magnetic field has been found. The decay is prevented by DNA double strand *bridges* that connect adjacent particles. If the bead surface has been prepared with a streptavidin coating, DNA can be linked to the beads with biotin. The beads are then covered with a layer of DNA strands. These strands are complementary to a linker-DNA. When the linker is added DNA single strands turn (hybridize) into DNA double strands. The hybridization between the linker strands and the oligonucleotides on the surface of the beads leads to a solidification of the monolayer, which originally has been produced and stabilized by the external rotating magnetic field. The DNA bridges can be broken and assembled through controlled temperature change.

MA 19.12 Tue 13:00 P1

Formation of ferrite nanoparticles monitored during the preparation process — •Mathias Kraken[1], Ingke-Christine Masthoff[2], Dennis Mauch[1], Dirk Menzel[1], Jochen Litterst[1], and Georg Garnweitner[2] — [1]Institut für Physik d. kond. Materie, TU Braunschweig — [2]Institut für Partikeltechnik, TU Braunschweig

In the recent years, a broad variety of different preparation methods for magnetic nanoparticles has been established. In this context, the nonaqueous sol-gel method is a rather new process, based on the bottom-up approach, which produces spherical nanoparticles with a small size distribution [1].

Mixtures of $Fe(acac)_3$ with e.g. benzyl alcohol are placed in a reactor at temperatures above room temperature (typically 200°C) for several hours. The physical properties of the formed particles strongly depend on the time spent in the reactor.

By examining extracted sample material for different waiting times in the reactor, we were able to follow the formation and the subsequent growth of the ferrite nanoparticles, using Mössbauer spectroscopy, DC-susceptibility and TEM [2,3].

[1] I.-M. Grabs et al., Cryst. Growth Des. 12, 1496 (2012).
[2] M. Kraken et al., Hyp. Int, published online, (2013).
[3] I.-C. Masthoff et al., in preparation.

MA 19.13 Tue 13:00 P1

Neutron diffraction and XMCD on $YFe_2O_{4-\delta}$ single crystals. — •Thomas Mueller[1], Yixi Su[2], Kirill Nemkovskiy[2], John Freeland[3], David Keavney[3], Richard A. Rosenberg[3], and Manuel Angst[1] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich, GERMANY — [2]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at MLZ Lichtenbergstraße 1, 85747 Garching, GERMANY — [3]Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, Illinois 60439, USA

$YFe_2O_{4-\delta}$ is isostructural to $LuFe_2O_4$ the former primary example for a charge order multiferroic, but the ionic radius of Y is much larger compared to Lu, leading to completely different ordering phenomena. We have grown highly stoichiometric single crystals of $YFe_2O_{4-\delta}$ by the optical floating zone method, showing for the first time 3D charge and magnetic ordering. Here we present single crystal neutron diffraction performed at the DNS instrument at the MLZ, with full polarization analysis to distinguish magnetic from charge-order scattering and to determine the magnetic moment directions. We were able to identify contributions from three magnetic domains arranged in a 120° pattern. XMCD measurements at 4-ID-C at the APS were performed to probe for orbital contributions and to get valance specific information about the magnetic moments.

MA 19.14 Tue 13:00 P1

Magnetic linear dichroism in angular resolved photoemission of the valence band of Co (0001) thin films — •Tobias Löffler[1], Torsten Veltum[1], Sven Döring[2], Lukasz Plucinski[2], and Mathias Getzlaff[1] — [1]Institut für Angewandte Physik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf — [2]Peter Grünberg Institut PGI-6, Forschungszentrum Jülich, 52428 Jülich

The Magnetic linear dichroism in the angular distribution (MLDAD) of photoelectrons technique allows the study of the magnetic band structure as well as the magnetic properties of metallic thin films and single crystals. We are interested in a deeper understanding of the magnetic linear dichroism of ferromagnetic 3d metals. Special attention is turned to the question, which parts of the band structure are responsible for this phenomenon. In this study, linearly polarized synchrotron radiation in the VUV regime is used (Beamline 5, DELTA Dortmund). The system under study consists of a thin hcp Co (0001) film which was epitaxially grown on a W(110) surface.

To investigate the electronic structure of the valence band, the exiting photon energy is varied. At lower energies, existing dichroism measurements are confirmed [1] and extended to off-normal geometry. The angle-resolved measurements show a strong angle-dependence of the dichroism. Opposite effects for negative and positive detection angles have been observed and will be discussed

[1] J. Bansmann et al., Surf. Sci. 454-456 (2000), 686-691

MA 19.15 Tue 13:00 P1

Modifying the spin-dependent electronic properties of a Co nanoisland by Fe decoration — •Vasilii A. Sevriuk[1], Soo-hyon Phark[1], Jeison A. Fischer[1,2], Marco Corbetta[1], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Laboratório de Filmes Finos e Superfícies, Departamento de Física, Universidade Federal de Santa Catarina , Florianópolis, SC, Brazil

We present a spin-polarized scanning tunneling spectroscopy (STS) study to characterize the effect of the circumferential decoration of a biatomic-layer-high (BLH) Co nanoisland, containing some 5000 atoms, by a BLH Fe stripe on the spin-dependent electronic properties. The spin-dependent differential conductance of a Fe-decorated Co island shows an almost constant state in the Co core. Our position-dependent STS data show a spatially uniform Co minority state around -0.3 eV. This finding is in sharp contrast to a sign-inverted spin-dependent differential conductance at the rim of a pure Co island. The constant energy value of the Co minority state deviates from the previously reported pronounced spatial variation of the peak energy on the nm scale for pure Co islands. We suggest that structural relaxations of the Co core of Fe-decorated Co islands are considerably reduced as compared to pure Co islands, and we discuss the implications for the modified spin-dependent electronic structure of the Fe-decorated Co cores.

MA 19.16 Tue 13:00 P1

Momentum Microscopy (k-PEEM) with Time-of-Flight Dispersion and Imaging Spin Filter — S. Chernov[1], •K. Medjanik[1], F. Schertz[1], D. Panzer[1], H.J. Elmers[1], C. Tusche[2], A. Krasyuk[2], J. Kirschner[2], and G. Schönhense[1] — [1]JGU, Inst. für Physik, D-55099 Mainz — [2]MPl für Mikrostrukturphysik, D-06120 Halle

Direct parallel imaging of momentum space is a highly effective method for electronic bandstructure mapping [1]. This approach utilizes the special imaging properties of a cathode-lens, aiming at an ultimate resolution in k-space. In the present work we employ a time-of-flight section as imaging energy filter in combination with a 3D (x,y,t)-resolving delay line detector. Further, an imaging spin filter of Ir(001) type [2] is integrated. The ToF k-microscope detects a certain energy interval in parallel. Cuts through k-space are obtained from the full data set via the corresponding flight-time condition. The spin information can be obtained by switching between spin-integral and spin-filtered branches of the microscope. In the spin-selective branch momentum conservation in the LEED process ensures sharp images with very high signal-to-background discrimination (owing to the ToF filter) and very high spatial resolution. High spin contrast of >70% has been found [2], in good agreement with recent results on Au-covered Ir(100) [3]. First measurements employ a fs laser for excitation, the status of the experiment is reported. Funded by BMBF (05K12UM2 and 05K12EF1).

[1] A. Winkelmann et al., PRB 86 (2012) 085427;
[2] D. Kutnyakhov et al., Ultramicroscopy 130 (2013) 63;
[3] J. Kirschner et al., PRB 88 (2013) 125419

MA 19.17 Tue 13:00 P1

A large-scale quantum simulator on a diamond surface at room temperature — Jianming Cai[1,2], •Thomas Unden[4,2], Florian Fetzer[4,2], Boris Naydenov[4,2], Liam McGuinness[4,2], Alex Retzker[3,1], Martin B. Plenio[4,2], and Fedor Jelezko[1] — [1]Institut für Theoretische Physik, Albert-Einstein Allee 11, Universität Ulm, 89069 Ulm, Germany — [2]Center for Integrated Quantum Science and Technology, Universität Ulm, 89069 Ulm, Germany — [3]Racah Institute of Physics, The Hebrew University of Jerusalem, Jerusalem 91904, Givat Ram, Israel — [4]Institut für Quantenoptik, Albert-Einstein Allee 11, Universität Ulm, 89069 Ulm, Germany

Strongly correlated quantum many-body systems may exhibit exotic phases, such as spin liquids and supersolids. Although their numerical simulation becomes intractable for as few as 50 particles, quantum simulators offer a route to overcome this computational barrier. However, proposed realizations either require stringent conditions such as low temperature/ultra-high vacuum, or are extremely hard to scale. Here, we propose a new solid-state architecture for a scalable quantum Simulator that consists of strongly interacting nuclear spins attached to the diamond surface. Initialization, control and read-out of this quantum simulator can be accomplished with nitrogen-vacancy centers implanted in diamond. The system can be engineered to simulate a wide variety of strongly correlated spin models. Owing to the superior coherence time of nuclear spins and nitrogen-vacancy centers in diamond, our proposal offers new opportunities towards large-scale quantum simulation at ambient conditions.

MA 19.18 Tue 13:00 P1

Interaction Effects in Micro- and Nanoscale Magnetic Samples studied by First Order Reversal Curves — •Luigi Ventura[1], Martin Lonsky[1], Merlin Pohlit[1], Yuzo Ohno[2], Hideo Ohno[2], and Jens Müller[1] — [1]Physikalisches Institut, Goethe-Universität, Frankfurt (M), Germany — [2]Laboratory for Nanoelectronics and Spintronics, Tohoku University, Sendai, Japan

Magnetic hysteresis is usually measured to determine sample-specific parameters such as the coercive field and the remanent magnetization and provides a measure of the bulk magnetic properties. Pike et al. have developed a method to gain more insight into magnetic interaction effects by the acquisition of a class of minor loops known as first order reversal curves (FORCs) [1]. Here, we discuss the application of the FORC method to micro- and nano-sized magnetic structures by combining it with micro-Hall magnetometry. The latter is an ultrasensitive technique suitable for measuring small arrays and even individual magnetic particle positioned on top of the Hall sensor. Our sensors are based on a high-mobility two-dimensional electron gas in a GaAs/AlGaAs heterostructure and allow for measuring a Hall voltage which is proportional to the z-component of the local magnetic stray field. We discuss different magnetic systems, as e.g. the interaction between individual ferromagnetic micro-grains or coupling effects in an artificial spin-ice structure.

[1] C. R. Pike et al., J. Appl. Physics 85, 9 (1999).

MA 19.19 Tue 13:00 P1

Element-selective magneto-optics employing circularly polarized EUV radiation from a tabletop plasma EUV source — •Daniel Wilson[1,2,4], Denis Rudolf[1,2,4], Roman Adam[3,4], Serhiy Danylyuk[4,5], Claus M. Schneider[3,4], Detlev Grützmacher[2,4], and Larissa Juschkin[1,2,4] — [1]RWTH Aachen University, Experimental Physics of EUV, Steinbachstrasse 15, 52074 Aachen, Germany — [2]Peter Grünberg Institut (PGI-9), Research Centre Jülich GmbH, 52425 Jülich, Germany — [3]Peter Grünberg Institut (PGI-6), Research Centre Jülich GmbH, 52425 Jülich, Germany — [4]JARA - Fundamentals of Future Information Technology — [5]RWTH Aachen University, Chair for Technology of Optical Systems, Steinbachstrasse 15, 52074 Aachen, Germany

Magneto-optical methods using visible light are able to detect a small magnetization, but they hardly can be applied for element-selective studies. On the other hand, if the wavelength of light matches an atomic absorption edge, the measurement becomes element- and thus layer-selective. The $M_{2,3}$ absorption edges of the technologically important ferromagnetic elements Fe, Co and Ni are located in the extreme ultraviolet (EUV) spectral region. In our work, we generate circularly polarized light at 54 eV, 60 eV and 67 eV corresponding to the $M_{2,3}$ absorption edges of Fe, Co and Ni from an intense, laboratory-based gas discharge plasma EUV source. In addition, we developed an ellipsometer consisting of a linear multilayer polarizer, a circular triple reflection polarizer and an analyzer, allowing us to perform x-ray magnetic circular dichroism measurements.

MA 19.20 Tue 13:00 P1

Nanoscale sensing of a magnetic topology at room & low

temperature — •Alexander Gerstmayr[1], Phani Peddibhotla[1], Dominik Reitzle[1], Berndt Koslowski[1], Markus Morgenstern[2], and Fedor Jelezko[1] — [1]Ulm University, Ulm, Germany — [2]RWTH Aachen, Aachen, Germany

For years, the nitrogen-vacancy (NV) center in diamond has been in the spotlight for studies of electron spin oupling. Also the coupling to other nearby color centers in diamond was studied recently. We will explore single atom control techniques for sensing external spins and imaging them using scanning probe microscopy. External magnetic fields cause a frequency shift of the electron spin resonance of our NV-center, which is detectable by Optically Detected Magnetic Resonance (ODMR). One single NV-center located in a diamond tip is the main part of the future Atomic-Force- and Magnetic-Resonance-Microscope (AFM/MRM). Due to the possibility of single-spin detection with NV-centers under ambient conditions, this combination of AFM and MRM is planned to work even at room temperature but also at low temperature (4K). We will be able to locate single spins on the nanoscale.

MA 19.21 Tue 13:00 P1

Capacitance and polarization of multiferroics at high magnetic fields — •Zhao-Sheng Wang, Joseph Law, Erik Kampert, Thomas Herrmannsdörfer, and Joachim Wosnitza — Hochfeld-Magnetlabor Dresden (HLD), Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden, Germany

We have investigated the multiferroic compound $LiCuVO_4$ by means of capacitance and polarization measurements. For that purpose we have developed an experimental setup for capacitance and dielectric polarization measurements which can be operated in high pulsed magnetic field. The capacitance is measured using a high precision capacitance bridge (GR1615-A) which is balanced before the pulse. In order to avoid electrical noise arising from the magnetic-field pulse, we operate the capacitance bridge at frequencies above 10 kHz. The excitation signal and the voltage of the bridge circuit are recorded by a digital oscilloscope at a high sampling rate (1 MS/ s) and high resolution (16 bit). Signal postprocessing is performed by a computational lock-in procedure providing a resolution on the 10^{-15} F scale. Using that technique, we were able to demonstrate the occurence of a phase transition of $LiCuVO_4$ in pulsed magnetic fields. In future, the experimental setup will be used for mapping out phase diagrams of further materials, such as multiferroics which exhibit phase transitions at very high magnetic fields).

MA 19.22 Tue 13:00 P1

New sample holder for XPEEM with an optical focusing lens — •Lukas Gierster[1,2], Leo Pape[3], Akin Ünal[2], Sergio Valencia[2], and Florian Kronast[2] — [1]Technische Universität Berlin — [2]Helmholtz-Zentrum-Berlin (BESSY) — [3]Ernst-Moritz-Arndt-Universität Greifswald

We describe a new sample holder for the X-Ray Photoemission Electron Microscope (XPEEM) which enables focusing femtosecond Laser pulses to their diffraction limited spot sizes (i. e. 1-2 μm). With this sample holder we can create local and ultrashort excitations in magnetic systems. The spread of excitations in lateral as well as temporal dimensions can be investigated using the XPEEM magnetic imaging technique at Bessy II synchrotron.

MA 19.23 Tue 13:00 P1

Sensing magnetic fields with a nuclear spin based diamond magnetometer — •Alexander Stark[1], Boris Naydenov[1], Alex Retzker[2], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Universität Ulm, D-89073 Ulm, Germany — [2]Racah Institute of Physics, The Hebrew University of Jerusalem, Jerusalem 91904, Israel

Single defect centres in diamond and especially the nitrogen-vacancy (NV) show remarkable physical properties, making them ideal candidates for single photon sources, qubits and nano-scale magnetic field sensors[1]. Here we present a novel scheme for detecting magnetic fields using single nuclear spins coupled to a single NV in a bulk diamond crystal. Our method relies on a quantum non-demolition read-out[2,3] of a neighbouring ^{13}C nuclear spin which is used as the actual sensor. Additionally we apply an error correction protocol in order to improve the sensitivity. The results are compared with the experimental realizations. We believe that our method can find application in the emerging field of diamond magnetometry.

[1] M. Doherty et al., *Physics Reports* **528**, 1 (2013)
[2] P. Neumann et al., *Science* **329**, 542 (2010)
[3] P. C. Maurer et al., *Science* **336**, 1283 (2012)

MA 19.24 Tue 13:00 P1

Direct Measurement of the Magnetocaloric Effect via Magneto-modulation Infrared Radiometry — •Jago Döntgen, Jörg Rudolph, and Daniel Hägele — AG Spektroskopie d. kondensierten Materie

The temperature change ΔT exhibited by a material under adiabatic application of a magnetic field is of major interest for both the understanding of its magnetocaloric properties and the assessment of its potential as an energy efficient magnetic refrigerant. The systematic investigation of materials with varying element compositions requires a method to measure temperature changes in small volume samples or even thin films which excludes traditional calorimetry. Here, we measure the temperature change of low volume samples via detection of its thermal radiation in a magnetic field that is modulated at frequencies of up to 100 Hz with up to 40 mT amplitude. The fast modulation establishes adiabatic conditions by keeping up with the fast thermal equilibration of small samples. Temperature dependent measurements of ΔT in Gadolinium and LaFeSi between 270 and 310 K exhibit maxima close to their Curie temperatures as expected for the MCE. The high sensitivity of our new approach (few mK) allows for the first time to verify in the low field range of Gadolinium a quadratic dependence of the temperature change on the magnetic field.

MA 19.25 Tue 13:00 P1

Nanoscale magnetic field sensing using single NV defects — •Vinaya Kumar Kavatamane, Sri Ranjini Arumugam, Andrii Lazariev, and Gopalakrishnan Balasubramanian — Max Planck Research Group 'Nanoscale Spin Imaging', Max Planck Institute for Biophysical Chemistry, Goettingen 37077, Germany

Nitrogen-vacancy (NV) color centers in diamond are atomic sized point defects which enable sensing and imaging of external magnetic fields at nanoscale without requiring low temperatures for their operation. A nanodiamond crystal hosting a single NV center attached to the scanning probe is used as a nanoscale magnetometer. The NV spin states are addressed by microwaves and the optically detected magnetic resonance spectra of the NV center enables the sensing of the external weak magnetic fields. We will present some preliminary results on measuring magnetic fields at nanometer length scales.

MA 19.26 Tue 13:00 P1

Spin-dependent reflection and absorption maps of Fe(001)-p(1x1)-O — •Christian Langenkämper[1], Christian Thiede[1], Kaito Shirai[2], Anke B. Schmidt[1], Taichi Okuda[3], Stephan Borek[4], Jan Minár[4], Jürgen Braun[4], Hubert Ebert[4], and Markus Donath[1] — [1]Physikalisches Institut, Universität Münster, Germany — [2]Graduate School of Science, Hiroshima University, Japan — [3]Hiroshima Synchrotron Radiation Center, Hiroshima University, Japan — [4]Ludwig-Maximilians-Universität München, Germany

Today, the most efficient spin-polarization detectors are based on low-energy scattering from oxygen-passivated Fe(001) targets. They combine long-term stability with a high figure of merit [1,2]. The working points have been described at the spin asymmetry maxima at energies between 6 eV and 13.5 eV and scattering angles between 12 and 15 degrees. We performed reflection and absorption measurements for Fe(001)-p(1x1)-O over a wide range of scattering angles and energies. We compare spin-asymmetry maps for absorption and reflection with theoretical data in view of application in spin-polarization detectors.

[1] Winkelmann *et al.*, Rev. Sci. Instrum. **79**, 083303 (2008)
[2] Okuda *et al.*, Rev. Sci. Instrum. **79**, 123117 (2008)

MA 19.27 Tue 13:00 P1

Surfactant Mediated Growth of Magnetic Multilayers: X-ray and Neutron Reflectivity Study — •Amir Syed Mohd[1,2], Mukul Gupta[2], Ajay Gupta[2], and Jochen Stahn[3] — [1]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at MLZ, Lichtenbergst. 1, 85748 Garching, Germany — [2]UGC-DAE Consortium for Scientific Research, Khandwa Road Indore-452001, India — [3]Laboratory for Neutron Scattering, PSI, CH-5232 Villigen PSI, Switzerland

In magnetic multilayers, often magnetic materials are separated by non-magnetic noble metals, semiconductors or insulators. In general, noble metals and insulators have smaller surface free energy (γ) values as compared to magnetic materials. This difference in γ of materials leads to asymmetric interface during the growth of the magnetic multilayers[1].

While γ being an intrinsic property of the material, energy of adatoms condensing on a substrate also affects thin film growth. Generally, the energy of adatoms is characterized by a deposition process. Although, surfactant mediated growth of magnetic multilayers has been studied [2], but the study of influence of adatom energy is still lacking. In the present work we studied Ag surfactant mediated growth of miscible (Ni/Ti) and immiscible (Cu/Co) multilayers prepared using different deposition techniques viz. e-beam evaporation and ion beam sputtering. Obtained results will be presented and discussed in this presentation. [1] F. J. Himpsel et al Adv. Phys. 1998, 47, 511 [2] H. D. Chopra et al Phys. Rev. B 2002, 65, 094433

MA 19.28 Tue 13:00 P1

Element-selective investigation of magnetic domain structure in CoPd and FePd alloys using small-angle soft X-ray scattering. — Christian Weier[1], •Roman Adam[1], Robert Frömter[2], Judith Bach[2], Björn Beyersdorff[2], Kai Bagschik[2], Hans Peter Oepen[2], Leonard Müller[3], Stefan Schleitzer[3], Magnus Berntsen[3], Gerhard Grübel[3], and Claus Michael Schneider[1] — [1]Peter Grünberg Institut, PGI-6 & JARA-FIT, Forschungszentrum Jülich, 52425, Jülich, Germany — [2]Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355, Hamburg, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, 22607 Hamburg, Germany

Recent optical pump-probe experiments on magnetic multilayers and alloys identified perpendicular spin superdiffusion as one of the possible mechanisms responsible for femtosecond magnetization dynamics. On the other hand, ultrafast lateral spin transport needs to be further understood in detail. To address this question, we studied the magnetic domain structure of CoPd and FePd thin films using small-angle scattering of soft X-rays. Applying in-situ magnetic fields resulted in pronounced rearrangement of domain structure that was clearly observed in scattering images. Our analysis of both the stand-alone, as well as magnetically coupled CoPd/FePd layers provides insight into the formation of domains under small magnetic field perturbations and paves the way to better understanding of transient changes expected in magneto-dynamic measurements.

MA 19.29 Tue 13:00 P1

Inelastic MIEZE Measurements — •Tobias Weber[1,2], Georg Brandl[1,2], Robert Georgii[2], and Peter Böni[1] — [1]Physik Department E21, Technische Universität München, 85748 Garching, Germany — [2]Heinz-Maier-Leibnitz-Zentrum, Technische Universität München, 85748 Garching, Germany

We report on a further development of the MIEZE method for inelastic measurements of ferromagnetic samples. MIEZE is a spin-echo method similar to neutron resonance spin-echo (NRSE) [1], but with the entire polarisation analysis taking place before the sample, thus making it ideally suited for studying depolarising materials. The MIEZE instrument option [2] and the recent development of a triple-axis spectrometry (TAS) option at the instrument MIRA [3] made it possible to combine both methods into a single setup. Using TAS we can position the instrument at the specified (q, E) values given by the dispersion relation of the magnetic excitations and measure their linewidth using MIEZE at a higher resolution than that given by a pure TAS. Due to inelastic energy transfer at the sample, corrections have to be taken into account for calculating the focus point of the MIEZE signal. We present a theoretical model, Monte-Carlo simulations and first experimental results of our measurements.

[1] T. Keller et al., Scattering, Academic Press, London, pp. 1264-1286 (2002) [2] R. Georgii et al., Applied Physics Letters 98 073505 (2011) [3] R. Georgii et al., E21 Annual Report 2011/12, p. 43 (2013)

MA 19.30 Tue 13:00 P1

Tailored charges in Néel walls by tailoring anisotropies in artificial domains in exchange bias layer systems — •Alexander Gaul, Martin Wilke, Dennis Holzinger, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

The angle between the magnetization orientation of adjacent in-plane magnetized domains and the angle of the magnetizations relative to the domain wall plane was systematically varied in topographically flat exchange bias samples by ion bombardment induced magnetic patterning (IBMP). The different domain configurations reveal different amounts of magnetic charges in the domain walls, hence, leading to different charge contrasts in the magnetic force microscope (MFM) signals. The experiments are compared to simulations, where the magnetic charge contrast was obtained from the spatial magnetization distribution of the sample calculated by the object oriented micromagnetic framework (Oommf). The experimental and simulation data was analyzed for changes in domain wall widths, symmetries and the relative amounts of magnetic net charges. These experiments highlight the ability to tailor domain walls, magnetic charges and therefore magnetic stray fields in one and the same layer system.

MA 19.31 Tue 13:00 P1

Improved Sensitivity for Ferromagnetic Resonance Measurements — •Anja Banholzer[1], Kilian Lenz[1], Ryszard Narkowicz[2], and Jürgen Lindner[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Universität Dortmund

Nowadays the need for magnetic characterization of nanoscale ferromagnets is required. With conventional measurement methods it is usually necessary to measure a large array of the nano-sized objects of interest due to the low number of spins in the nanostructure. We developed a microresonator, which makes it possible to measure the ferromagnetic resonance on single nano-sized elements [1]. Conventional FMR needs at least 10ˆ12 Spins to gain a decent signal . With the microresonator a thousandth of magnetic volume can still be measured. Further optimizations on the microresonators allow to increase the filling factor and the sensitivity. We investigated magnetic trilayer system with different spacer thicknesses of 25nm and diameters of 500nm.

[1]A. Banholzer, et. al., Nanotechnology 22 (2011)

MA 19.32 Tue 13:00 P1

Spin-wave excitation and propagation in microstructured waveguides of yttrium iron garnet /platin bilayers — •Philipp Pirro[1], Thomas Brächer[1,2], Andrii Chumak[1], Carsten Dubs[3], Oleksii Surzhenko[3], Peter Görnert[3], Britta Leven[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Gottlieb-Daimler-Strasse 47, D-67663 Kaiserslautern — [3]Innovent e.V., Prüssingstraße 27B, 07745 Jena, Germany

In the field of magnon-spintronics, the investigation of propagating spin waves in micro-sized waveguides has attracted growing interest as they constitute the backbone of all magnonic circuits. Here, we present an experimental study of spin-wave excitation and propagation in microstructured waveguides patterned from a 100 nm thick yttrium iron garnet (YIG)/platinum (Pt) bilayer. The Pt capping enhances the Gilbert damping, but, nevertheless, the life time of the spin waves is more than an order of magnitude higher than in comparably sized metallic structures. Utilizing microfocus Brillouin light scattering spectroscopy, we reveal the spin-wave mode structure for different excitation frequencies. An exponential spin-wave amplitude decay length of up to 31 μm is observed.

Financial support by the OPTIMAS Car Zeiss Doktoranden Programm and the Graduate School Materials Science in Mainz is acknowledged.

MA 19.33 Tue 13:00 P1

Functional Approach to Electrodynamics in Media — •Ronald Starke — Institut f. theo. Physik, Bergakademie Freiberg

We put forward an approach to classical electrodynamics in media which identifies induced electromagnetic fields as the microscopic counterparts of polarization and magnetization and which systematically employs the mutual functional dependences of induced, external, and total field quantities. This allows for a unified, relativistic description of the electromagnetic response independent of any assumption about the material's possible composition of electric or magnetic dipoles. Using this approach we derive universal relations between electromagnetic response functions which reduce to well-known identities in special cases, but include more generally the effects of inhomogeneity, non-isotropy and relativistic retardation. We further provide general expressions for the constitutive dyadics of bianistropic media in terms of nine causal response functions as represented by the conductivity tensor.

MA 19.34 Tue 13:00 P1

Nanoscaled manganese-based hard magnetic materials — •Maik Scholz, Marcel Haft, Markus Gellesch, Sabine Wurmehl, Silke Hampel, and Bernd Buechner — Leibniz-Institute for Solid State and Materials Research - IFW, Dresden, Germany

Nanoscale magnetic materials are interesting not only from a scientific perspective, but also for potential use in industrial applications. The interest foremost arises because of the concomitant change in physical properties when scaling a bulk-material down to its smallest size. While intermetallic materials may be highly sensitive to oxidation at the nanoscale, this is less a problem in oxide materials; yet in both cases, we found that the encapsulation of magnetic nanoparticles inside carbon nanotubes via a wet-chemical process is a versatile tool to control oxidation states of the filling materials. Furthermore the surrounding nanotube defines the maximum diameter for the filling particles which determines the magnetic properties of the filling material. Here we present results on the magnetic properties of several manganese oxides inside the cavity of carbon nanotubes. The samples were investigated by magnetometry besides electron microscopy, X-ray diffraction and energy dispersive X-ray spectroscopy. The nanoparticles inside carbon nanotubes exhibit enhanced magnetic performance which is most visible in the increased coercitivity (0.92 MA/m) which is higher than the respective bulk material (0.24 MA/m). In future we aim to control the oxidation state of manganese in a way that allows us, also to synthesize nanoparticles of binary or ternary manganese-based intermetallic materials inside the inner cavity carbon nanotubes.

MA 19.35 Tue 13:00 P1

Building Blocks of an Artificial Square Spin Ice: Stray Field Studies using micro Hall-Magnetometry — •Merlin Pohlit, Evgeniya Begun, Fabrizio Porrati, Michael Huth, and Jens Müller — Physikalisches Institut, Goethe-Universität, Max-von-Laue-Str. 1, D-60438 Frankfurt am Main, Germany

Besides fundamental aspects of frustration, disorder and degeneracy, spin ice systems allow for studying new physical phenomena like the topological Coulomb phase and the occurrence of magnetic monopoles. Due to the ability to tune the geometric shape and the possibility to access spatially resolved magnetic properties, artificial spin ice systems, i.e. nanostructured arrays of macroscopic spins, have come to the fore of recent research interest. Here we present magnetic measurements performed on individual building blocks of artificial square spin ice. For this purpose a cobalt-based spin ice structure was grown by focused electron beam induced deposition (FEBID) onto the surface of a lithographically defined μm-sized Hall-sensor based on a two dimensional electron gas of an AlGaAs/GaAs heterostructure. This setup provides continuous access to the array's stray field during magnetic reversal. Results from temperature- and magnetic field-dependent stray field measurements, including minor loops, will be shown and compared to micro magnetic simulations.

MA 19.36 Tue 13:00 P1

Surface crystallization and magnetic properties in Fe84.3Cu0.7Si4B8P3 and Fe85Cu1Si2B8P4 soft magnetic ribbons — •Elena Lopatina[1], Ivan Soldatov[1], Rudolf Schäfer[1,2], Giselher Herzer[3], and Ludwig Schultz[1,2] — [1]IFW Dresden, Institute for Metallic Materials, Helmholtzstrasse 20, D-01069 Dresden, Germany — [2]Institute for Materials Science, TU Dresden, Mommsenstraße 9, D-01069 Dresden, Germany — [3]VACUUMSCHMELZE GmbH & Co. KG, Grüner Weg 37, D-63450 Hanau, Germany

In this work, as cast ribbons of Fe84.3Cu0.7Si4B8P3 and Fe85Cu1Si2B8P4 alloys have been annealed at temperatures in the interval 370-550 C in order to bring their amorphous structure into the nanocrystalline state and, as a result, to improve magnetic properties for posterior applications. Structural investigations (XRD) of as cast ribbons have shown that, in the case of the Fe84.3Cu0.7Si4B8P3 alloy, the ribbon surface possesses a strongly textured crystalline structure of large- scale α-Fe particles, while the other alloy, Fe85Cu1Si2B8P4, has slightly crystallized surfaces with randomly oriented α-Fe crystallites. In compliance with the model proposed by Ok and Morrish [1], magneto-optical Kerr investigations confirmed that the surface crystallization causes the development of perpendicular anisotropy in the amorphous bulk. However, the development of in-plane anisotropy on the surface is pronounced only for the alloy with strong surface texture, while the ribbons of the other alloy show no evidence of in-plane anisotropy on the surface. [1] H.N. Ok and A.H. Morrish, Phys. Rev. B 23 (1981) 2257.

MA 19.37 Tue 13:00 P1

Controlled pinning of magnetic Fe and Pt pillars created by electron beam induced deposition — Johannes J.L. Mulders and •Daniela Sudfeld — FEI Electron Optics B. V., Eindhoven, The Netherlands

Electron beam induced deposition is a direct write patterning technique, using the electron beam of a scanning electron microscope (SEM) to locally dissociate injected precursor molecules adhered to a surface. The details of the FEI EBID technique are described elsewhere [1]. The lateral patterning is done with nano-scale accuracy and the vertical growth is controlled by the dwell time, the technique offers a mask-free patterning capability in 3 dimensions. Recently the material quality of the actual deposition of magnetic materials such as Co, Fe and Pt, has reached a purity level above 70 at%, enabling the creation of prototype nano-scale magnetic structures [2] like for instance Fe Pillars on a predefined PtCoPt circuit path. The current status of the technology for creating ferro-magnetic structures will be presented, including the practical limits. In addition, results of the controlled pinning and the modulation of domain wall pinning sites are presented. [1] Utke I, Moshkalev S, Russell P: Nanofabrication Using Focused Ion and Electron Beams, Chapter 10, Oxford University Press (2012); [2] Lavrijsen R et al, Nanotechnology 22 (2011) 025302.

MA 19.38 Tue 13:00 P1

Parallel parametric amplification of externally excited spin waves in a microstructured $Ni_{81}Fe_{19}$ waveguide — •Thomas Braecher[1,2], Philipp Pirro[1], Thomas Meyer[1], Alexander A. Serga[1], and Burkrad Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Gottlieb-Daimler-Strasse 47, 67663 Kaiserslautern, Germany

Recently, the capability of parallel parametric amplification [1] to amplify thermal spin waves in microstructured elements has been demonstrated [2,3].

Here, we report on the parallel parametric amplification of spin waves which have been externally excited by a microstrip antenna. We show that the amplified spin waves can be detected over a distance of 30 μm, which is quite large in comparison to the spin-wave decay length of 6.3 μm for the investigated geometry. The experimental observation is carried out using microfocussed Brillouin light scattering spectroscopy.

Thomas Brächer is supported by a fellowship of the Graduate School Materials Science in Mainz (MAINZ) through DFG-funding of the Excellence Initiative (GSC 266).

[1] E. Schlömann et al., J. Appl. Phys. **31**, 386S (1960)
[2] T. Brächer et al., Appl. Phys. Lett. **99**, 162501 (2011)
[3] T. Brächer et al., Appl. Phys. Lett. **103**, 142415 (2013)

MA 19.39 Tue 13:00 P1

Thermal ordering in a 2D artificial Ising system — •Henry Stopfel[1], Unnar Arnalds[1], Vassilios Kapaklis[1], Oliver Bärenbold[1], Marc Verschuuren[2], Ulrike Wolff[3], Volker Neu[3], and Björgvin Hjörvarsson[1] — [1]Department of Physics and Astronomy, Uppsala University, Sweden — [2]Philips Research Laboratories, Eindhoven, Netherlands — [3]Institute of Metallic Materials, IFW Dresden, Germany

Thermally active nano-patterned arrays composed of dipole coupled macrospins provide a means for investigating the thermal ordering of artificial spin systems.

Here we present a direct experimental investigation of the thermal ordering in a two dimensional Ising system composed of an array of elongated amorphous CoFeZr thin film islands. The shape anisotropy of the elongated magnetic islands confines the magnetization to a fixed axis creating Ising-like macrospins. During the growth of the array thermalization occurs providing a limited time window for thermal dynamics. As the islands become thicker the dynamics slow down and the thermalized state of the array becomes frozen in. Subsequently, the thermally ordered as-grown state can be locally investigated by magnetic force microscopy allowing a statistical analysis of the ordering of the artificial spins to be performed.

MA 19.40 Tue 13:00 P1

The influence of the magnetic field on the dynamics of the Goethite nanoplates probed by X-ray Photon Correlation Spectroscopy — •Alexander Schavkan, Fabian Westermeier, Alexey Zozulya, Birgit Fischer, Alessandro Ricci, Martin Schroer, Michael Sprung, and Gerhard Grübel — DESY Deutsches Elektronen-Synchrotron, Hamburg, Deutschland

Recent research on nano-particles led to significant advances on the development of new materials. Lately, experiments on the externally controlled behaviour of "smart nanoparticles" were of particular interest. These particles can be controlled by changing environmental conditions. The straight forward attempt is to investigate the behaviour of the particles during changes of the parameter, which they are sensitive to.

The outstanding magnetic properties of the different phases of Goethite are well studied. Still no approach was done to investigate the dynamics of the phases of Goethite suspensions and their transitions under applied magnetic field with XPCS. In the described experiment we synthesized Goethite suspensions with different concentrations. The underlying dynamics of these suspensions were probed by XPCS. First we measured the dynamics of the suspensions without magnetic field. In the second part we applied different types of the magnetic fields: permanent one, which was induced by the permanent magnet and non-permanent, which was created by a custom magnetic chamber. The influence of the applied magnetic field and the changes of the field on the dynamics of the suspensions were studied.

MA 19.41 Tue 13:00 P1

Multiple-GPU accelerated FEM micromagnetic simulations — •Attila Kákay[1], Elmar Westphal[2], and Riccardo Hertel[3] — [1]Forschungszentrum Jülich, Peter Grünberg Insitut (PGI-6), Deutschland — [2]Forschungszentrum Jülich, PGI/JCNS-TA , Deutschland — [3]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg, CNRS UMR 7504, Strasbourg, France

The micromagnetic study of large and realistic systems, like rolled-up ferromagnetic nanotubes, artificial spin-ice lattices, or magnonic crystals poses a challenge to simulation studies, as their calculation may involve tens of millions of degrees of freedom. We recently made an important step toward the simulation of such large systems by adapting our micromagnetic Finite-Element software `TetraMag` to the massively parallel architecture of Graphical Processing Units (GPUs)[1]. But for large-scale simulations, the matrices required for the calculation of the effective fields can outgrow the memory capacity of a single GPU. By carefully redesigning our code, especially the magnetostatic field calculation and the integration of the Landau-Lifshitz-Gilbert equation, we can now distribute a simulation over several GPUs. This is achieved by reordering and splitting the matrices in a checkerboard style, which enables us to reduce and/or hide time-consuming data transfers that often have a large impact on the performance of multi-GPU algorithms. As a benchmark example we will discuss the spin wave dispersion and magnetic structures developing in the hysteresis loop of a 300 nm diameter and 4 μm long rolled-up Permalloy tube.

[1] A. Kákay, E. Westphal, R. Hertel, IEEE Trans. Mag. 46, 2303 (2010)

MA 19.42 Tue 13:00 P1

A Multi-Scale Approach to High Resolution Magnetization Dynamics Simulations — •Andrea De Lucia and Benjamin Krüger — Institut für Physik, Johannes Gutenberg - Universität, Mainz

Current simulation tools for magnetic nanostructures either base on the micromagnetic model or the Heisenberg spin model. While the former model is suitable for systems with micrometer size it cannot be realistically applied to systems involving magnetization patterns of an atomic size like thermal spin-waves, vortex switching, Bloch points, edge roughness and narrow domain walls. For such simulations the Heisenberg spin model is used. But with this model it is not possible to simulate systems that reach experimentally used sizes.

Multi-Scale approaches are a very well established method to perform simulations in statistical mechanics when the microscopic properties of a macroscopic system are concerned. In this work we use such an approach in magnetization dynamics, using a domain-partitioned model in order to solve the Landau-Lifshitz-Gilbert equation in a mesoscopic sample. For the implementation of these multiscale simulations the micromagnetic simulation tool MicroMagnum[1] is extended to include the Heisenberg spin model.

[1] http://micromagnum.informatik.uni-hamburg.de/

MA 19.43 Tue 13:00 P1

quantitative magnetic imaging at the nanometer scale by ballistic electron magnetic microscopy — •hervé marie[1,2], sylvain tricot[1], sophie guézo[1], gabriel delhaye[1], bruno lépine[1], philippe schieffer[1], and pascal turban[1] — [1]Département Matériaux-Nanosciences - Institut de Physique de Rennes, Rennes, France — [2]Physikalisches Institut, Karlsruhe Institute of Technology (KIT),Karlsruhe, Germany

Ballistic Electron Magnetic Microscopy (BEMM) is a unique experimental tool allowing characterization of electronic properties of buried interfaces with nanometric lateral resolution. In BEMM experiments, hot electrons are injected from an STM tip into a spin-valve/semiconductor heterostructure. The hot electron current collected at the back of the substrate is modulated by magnetoresistive effects.

We report in this communication an investigation of sub-micrometric spin valves Fe/Au/Fe/GaAs with an Fe electrode evaporated through a nanostencil. In these structures, the modulation of the collected current by the local magnetic domain structure in the Fe dots allows magnetic imaging of buried nanostructures with strong contrast (500%) and a nanometric lateral resolution. The experimental magnetocontrast observed on these sub-micrometric Fe dots are in excellent agreement with BEEM current maps calculated via micromagnetic simulations. This opens the way to a quantitative magnetic microscopy technique with a high sensitivity and a nanometric lateral resolution [1].

[1] M. Hervé et al., J. Appl. Phys. 113, 233909 (2013)

MA 19.44 Tue 13:00 P1

Time- and spatially-resolved imaging of magnetization dynamics using threshold magnetic circular dichroism — •Maximilian Staab[1,2], Florian Schertz[1], Hans-Joachim Elmers[1], Mathias Kläui[1,2], and Gerd Schönhense[1] — [1]Johannes Gutenberg Universität Mainz, Staudinger Weg 7, 55128 Mainz — [2]MAINZ Graduate School of Excellence, Staudinger Weg 9, 55128 Mainz

While the static magnetic properties of nanostructures have been investigated for many decades, the magnetization dynamics in the femto- and picosecond range that governs the ultimate device performance is not yet understood completely and has therefore become recently the focus of research. To determine the spin dynamics with spatial and time resolution, threshold magnetic circular dichroism[1] is used as a contrast mechanism that describes asymmetries of the photoemission yield dependent on the magnetization orientation in a solid. It can be used for magnetic imaging combining very good spatial- and femtosecond time-resolution. For our measurements we fabricated perpendicularly magnetized thin Co/Au films and investigated them using photoemission electron microscopy with magnetic sensitivity due to threshold magnetic circular dichroism. Adding a femtosecond laser based pump-probe setup we aim at imaging spatially resolved magnetization dynamics within the femtosecond timescale to understand effects such as ultrafast demagnetization[2]. Project funded by DFG EL172/15.

[1] K. Hild et al., Phys. Rev. Lett. 102, 057207, (2009)
[2] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250-4253, (1996)

MA 19.45 Tue 13:00 P1

Magnetic Circular Dichroism in Valence Band Photoemission — •Markus Rollinger[1], Philip Thielen[1,2], Pascal Melchior[1], Ute Bierbrauer[1], Sabine Alebrand[1], Christian Schneider[1], Michel Hehn[3], Stéphane Mangin[3], Mirko Cinchetti[1], and Martin Aeschlimann[1] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School of Materials Science in Mainz, Kaiserslautern, Germany — [3]Institut Jean Lamour, Université de Lorraine, France

Recently we have shown the imaging of magnetic domains of terbium cobalt (TbCo) thin film alloys by magnetic circular dichroism (MCD) via photoemission electron microscopy (PEEM), both in two-photon photoemission and in one-photon photoemission using laser excitation in the visible spectrum of light [1]. Here, we report that the imaging is even possible through a 10-nm-thick non-magnetic capping layer, proving its compatibility for industrial application. We also report first measurements on CoPt multilayer systems and discuss the possible microscopic origin of this MCD signal.

[1] P. Melchior et al., Phys. Rev. B 88, 104415 (2013)

MA 19.46 Tue 13:00 P1

Stroboscopic wide-field Kerr-microscopy on soft magnetic ribbons — •Christian Becker[1,2], Rudolf Schäfer[1], and Ludwig Schultz[1,2] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, 01171 Dresden — [2]Technische Universität Dresden, Institute for Materials Science, 01062 Dresden

Applied especially as cores in generators, motors or transformers soft magnetic materials are magnetized alternately in time. The observation of magnetic domains in a time-resolved way is of great interest if the excitation frequency exceeds the maximum resolution of the eye. A Kerr-microscopic setup using a strobed LED is presented. Wide-field imaging of magnetic domains in a time-resolved way during periodic magnetic excitation is thereby possible. MOKE hysteresis loops are obtained from the images by plotting the average gray value as a function of magnetic field. Quasistatic magnetization processes differ from those under dynamic excitation conditions. MOKE hysteresis loops on bulk magnetic ribbons exhibit a broadening with increasing frequency as also observed by inductive measurements. We compare the inductively measured loops, which contain information of the whole sample volume, with the optical measured loops sensitive only to the surface magnetization. To ribbons in the as-cast amorphous state as well as to annealed with induced surface crystallization. The dynamic behavior of the magnetic microstructure in cycling field and quasistatic magnetization processes is discussed.

MA 19.47 Tue 13:00 P1

Decoherence Imaging with Nitrogen Vacancies in Diamond — •Andrea Kurz[1], Anna Ermakova[1], Goutam Pramanik[2], Janming Cai[3], Boris Naydenov[1], Martin Plenio[3], Tanja Weil[2], and Fedor Jelezko[1] — [1]Institute of Quantum Optics, University Ulm, Germany — [2]Institute of Organic Chemistry III, University Ulm, Germany — [3]Insitute of Therotical Physics, University Ulm, Germany

The negatively charged Nitrogen Vacancy (NV-) centers in diamond are very promising candidates for magnetic field sensors[1]. NV- has an electron spin, whose state can be read out optically, shows very long coherence times and is very sensitive to proximal spins[2,3]. NV- experiences decoherence caused by a spin bath of biological systems very precisely. The effect is strongly dependent on the distance between NV- and bath. We want to measure the coherence depending on the distance of the metallo protein ferritin to the NV-, thus imaging the spin densities of the protein molecule. To bring the molecules close to the NV center in a controlled fashion, they are attached to an AFM tip, which is brought to the diamond, with NV- at a depth of 2-5nm beneath the surface. The coherence is then measured depending on the molecules position with respect to the NV-. This method is in principle applicable for any protein and thus a very promising candidate for decoherence sensing of molecules.

[1]J. Cole et.al. ,Nanotech., Vol. 20(49) (2009)[2]A. Gruber et.al., Science, Vol. 276(5321) (2009)[3]T. Staudacher et.al., Science, Vol. 339(6119) (2013)

MA 19.48 Tue 13:00 P1

Comment on magnetic domain contrast in wide-field Kerr microscopy of bulk specimens — •Dominik Markó[1,2], Rudolf Schäfer[1,2], and Ludwig Schultz[1,2] — [1]IFW Dresden, Institute for Metallic Materials, Helmholtzstr. 20, D-01069 Dresden — [2]TU Dresden, Institut für Werkstoffwissenschaft, D-01062 Dresden

Wide-field Kerr microscopy is based on an optical polarization microscope with Köhler illumination and provides immediate domain images of a certain sample area. MOKE loops are readily obtained by plotting the image intensity of selected sample areas as a function of the applied magnetic field and, by calibrating the domain contrast for applied saturation fields along different directions, it is possible to evaluate the domain contrast in a quantitative way.

In bulk specimens, however, the application of magnetic fields can lead to a significant phenomenon: due to the close distance of the objective lens to the sample, magnetic stray fields which emerge from the sample edges may cause a strong non-linear, position- and field-dependent Faraday effect in the objective. This leads to a field-dependent contribution to the domain contrast within the corresponding images and, therefore, to highly distorted hysteresis loops. In this presentation, this effect and its implications will be systematically analyzed on FeSi bulk samples.

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Sb_2Te_3 **ultrathin films on Si(111): magnetic surface doping and circular dichroism in angle-resolved photoemission spectroscopy** — •M. Eschbach[1], M. Patt[1], L. Plucinski[1], V. Feyer[1], G. Mussler[2], D. Grützmacher[2], and C.M. Schneider[1] — [1]Peter Grünberg Institut PGI-6, FZ Jülich, Germany — [2]Peter Grünberg Institut PGI-9, FZ Jülich, Germany

Three-dimensional topological insulators are novel states of quantum matter and are combining an insulating bulk energy gap with conducting Dirac-like states at the surface. These topological surface states (TSS) are due to strong spin-orbit coupling. They are topologically protected against back-scattering by time-reversal symmetry and exhibit a spin-polarized chiral structure. We study epitaxially grown thin films of intrinsically p-type doped Sb_2Te_3 by means of high-resolution angle- and spin-resolved photoemission spectroscopy. Bulk and surface doping with (non-) magnetic impurities and their influence on the electronic structure and spin polarization of the TSS are characterized in detail. Magnetic impurities should break the time-reversal symmetry which should lead to a bandgap opening close to the Fermi level i.e. a massive Dirac fermion state which should be visible in high-resolution ARPES. Furthermore, at our soft x-ray undulator beamline NanoESCA in ELETTRA/Trieste we perform circular dichroism experiments for different photon energies to indirectly probe the spin texture of the TSS. Subsequently, this data will be correlated to spin-polarized ARPES data measured using a recently developed highly efficient 2-dimensional spin-polarizing electron mirror.