Magnetism Division
Fachverband Magnetismus (MA)

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Overview of Invited Talks and Sessions

(Lecture Rooms H3, H10, H16 (Tuesday), H22, H23; Poster D)

Thyssen-Krupp Electrical Steel Dissertationspreis

Monday 12:30–14:10 H3
Four candidates will compete for the prize. Please attend!

PhD-Student Symposium jointly with jDPG

Tuesday 09:30 – 13:45 H16
Topological Defects in Magnetic Materials: from Devices to Cosmos

Focus Session "Magnetic Excitations: from surfaces down to adatoms (jointly with O)"

MA 10.1	Mon	15:00–15:30	H23	**Tailoring magnetic excitations in low-dimensional ferromagnets** — •Khalil Zakeri Lori
MA 10.2	Mon	15:30–16:00	H23	**Theory of spin waves in ultrathin ferromagnetic films** — •Roberto Muniz, Antonio Costa
MA 10.3	Mon	16:00–16:30	H23	**Magnetic excitations in all metallic nanostructures** — •Wulf Wulfhekel
MA 10.4	Mon	16:30–17:00	H23	**Magnetization dynamics derived from excitations of single magnetic atoms on surfaces** — •Alexander Ako Khajetoorians
MA 10.5	Mon	17:00–17:30	H23	**Theory of dynamical magnetic excitations in itinerant nanomagnets** — •Samir Lounis

Focus Session "Terahertz Spintronics"

MA 12.1	Tue	9:30–10:00	H10	**Ultrafast magnetization enhancement in metallic multilayers driven by superdiffusive spin current** — •Roman Adam, Chan La-O-Vorakiat, Marco Battiato, Dennis Rudolf, Justin M. Shaw4, Emrah Turgut, Pablo Maldonado, Stefan Mathias, Patrik Grychtol, Hans T. Nembach, Thomas J. Silva, Martin Aeschlimann, Henry C. Kapteyn, Margaret M. Murnane, Claus M. Schneider, Peter M. Oppeneer
MA 12.2	Tue	10:00–10:30	H10	**New frontiers of ultrafast spin manipulation: femtosecond spin superdiffusion** — •Marco Battiato
MA 12.3	Tue	10:30–11:00	H10	**Engineering of terahertz spin currents in magnetic heterostructures** — •T. Kampfrath, M. Battiato, P. Maldonado, G. Eilers, J. Nötzold, S. Mährlein, V. Zbarsky, I. Radu, F. Freimuth, Y. Mokrousov, S. Blügel, M. Wolf, P. M. Oppeneer, M. Münzenberg
MA 12.4	Tue	11:00–11:30	H10	**Ultrafast spin dynamics induced by laser-generated spin currents in metallic multilayers probed by non-linear magneto-optics** — •Alexey Melnikov
MA 12.5	Tue	11:30–12:00	H10	**Ultra-fast spin currents in transparent magnetic tunnel junctions** — •Andy Thomas

Focus Session "Magnetic Damping Phenomena in Thin Films and Nanostructures(jointly with DS)"

MA 31.1	Wed	15:00–15:30	H10	**An overview of magnetic damping in ferromagnets** — •Robert McMichael
MA 31.2	Wed	15:30–16:00	H10	**Magnetic Damping on Femtosecond Time Scales** — •Markus Münzenberg
MA 31.3	Wed	16:00–16:30	H10	**Two-Magnon Excitations: From Periodical Perturbations to Magnonic Crystals** — •Kilian Lenz
MA 31.4	Wed	16:30–17:00	H10	**Gilbert damping parameter from first-principles** — •Diemo Ködderitzsch, Sergiy Mankovsky, Hubert Ebert, Georg Woltersdorf
MA 31.5	Wed	17:00–17:30	H10	**Spin dynamics and relaxation in ferrimagnets** — Frank Schlickeiser, Sönke Wienholdt, Denise Hinzke, •Ulrich Nowak

Focus Session "Spin Current Devices"

MA 32.1	Thu	9:30–10:00	H10	**Spin Hall and spin Nernst effect from first principles** — •Ingrid Mertig
MA 32.2	Thu	10:00–10:30	H10	**Spin currents in ferromagnetic insulator/normal metal hybrids** — •Matthias Althammer
MA 32.3	Thu	10:30–11:00	H10	**From magnon flow to spin current and back** — •Andrii Chumak
MA 32.4	Thu	11:00–11:30	H10	**Interaction between spin waves and magnetic domain walls in insulating ferromagnets** — •Peng Yan
MA 32.5	Thu	11:30–12:00	H10	**Current driven domain wall dynamics controlled by proximity induced interface magnetization** — •Stuart Parkin

Invited Talks

MA 4.1	Mon	9:30–10:00	H10	**Breaking time reversal symmetry in topological insulators** — •Jagadeesh Moodera
MA 5.1	Mon	15:00–15:30	H10	**The THz response of topological insulator surface states** — •N. Peter Armitage
MA 7.1	Mon	9:30–10:00	H22	**Time-of-Flight Magnetic Flow Cytometry** — •Michael Helou, Mathias Reisbeck, Lukas Richter, Jacobus Bosch, Roland Stauber, Eckhard Quandt, Oliver Hayden
MA 17.1	Tue	9:30–10:00	H22	**Magnetometry to identify the origin of printed documents** — •Anna S. Semisalova, Vladimir N. Nikiforov, Nikolai S. Perov
MA 18.1	Tue	9:30–10:00	H16	**Skyrmions in magnets** — •Maxim Mostovoy
MA 18.2	Tue	10:00–10:30	H16	**Experimental studies of skyrmions in chiral magnets** — •Christian Pfleiderer
MA 36.1	Thu	9:30–10:00	H3	**Towards single Nanoparticle detection: Element Specific Ferromagnetic Resonance - Microresonators in ScanningTransmission X-ray Microscopy** — •Katharina Ollefs
MA 44.1	Thu	15:00–15:30	H3	**Spin-polarized scanning field emission microscopy and spectroscopy** — •Anika Schlenhoff

Topical Talks

MA 10.1	Mon	15:00–15:30	H23	**Tailoring magnetic excitations in low-dimensional ferromagnets** — •Khalil Zakeri Lori
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MA 12.5	Tue	11:30–12:00	H10	**Ultra-fast spin currents in transparent magnetic tunnel junctions** — •Andy Thomas
MA 18.5	Tue	11:15–11:45	H16	**Topological Defects and Quantum Computing** — •Simon Trebst
MA 18.6	Tue	11:45–12:15	H16	**Cosmic strings in multiferroics** — •Nicola Spaldin
MA 18.8	Tue	12:45–13:15	H16	**Topological physics: from quantum Hall Skyrmions to optical Chern lattices** — •Roderich Moessner
MA 18.9	Tue	13:15–13:45	H16	**Magnetricity and Magnetic Monopoles in Spin ice** — •Steve Bramwell
MA 31.1	Wed	15:00–15:30	H10	**An overview of magnetic damping in ferromagnets** — •Robert McMichael
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Symposium SYBD "Magnetic Particles in Biomedical Diagnostics and Therapy"

SYBD 1.1	Mon	15:00–15:30	H1	**Functionalization and Pharmaceutical Aspects of Magnetic Nanoparticles (Magnetic Carriers)** — •Urs O. Häfeli
SYBD 1.2	Mon	15:30–16:00	H1	**Fluid mechanical aspects of therapeutic application of suspensions of magnetic nanoparticles** — •Stefan Odenbach
SYBD 1.3	Mon	16:00–16:30	H1	**Magnetic Particle Imaging: A new Medical Imaging Modality** — •Thorsten Buzug
SYBD 1.4	Mon	16:30–17:00	H1	**Superparamagnetic iron oxide nanoparticles for MR-visible mesh implants and novel drug targeting models** — •Ioana Slabu, Anjali Roeth, Christiane Kuhl, Thomas Schmitz-Rode, Martin Baumann
SYBD 1.5	Mon	17:00–17:30	H1	**Magnetic measurement techniques assisting biomedical applications of magnetic nanoparticles** — •Lutz Trahms

Symposium SYSC "Strong Coupling in Solid State Quantum Systems"

SYSC 1.1	Tue	9:30–10:00	H1	**Exploring the Physics of Superconducting Qubits Strongly Coupled to Microwave Frequency Photons** — •Andreas Wallraff

SYSC 1.2	Tue	10:00–10:30	H1	**Hybrid Quantum Circuit with a Superconducting Qubit Coupled to an Electron Spin Ensemble** — •Yuimaru Kubo, Cecile Grezes, Igor Diniz, Jun-ichi Isoya, Vincent Jacques, Anais Dreau, Jean-François Roch, Alexia Auffeves, Denis Vion, Daniel Esteve, Patrice Bertet
SYSC 1.3	Tue	10:30–11:00	H1	**Hybrid Quantum Systems with Rare-Earth Ion Spin Ensemble** — •Pavel Bushev
SYSC 1.4	Tue	11:00–11:30	H1	**Quantum Coherent Coupling between a Mechanical Oscillator and an Optical Mode** — Ewold Verhagen, Dalziel Wilson, Vivishek Sudhir, Nicolas Piro, Albert Schliesser, •Tobias Kippenberg
SYSC 1.5	Tue	11:30–12:00	H1	**Exploring Quantum Light-Matter Interactions of Quantum Dots in Photonic Crystal Nanostructures** — •Jonathan Finley, Arne Laucht, Michael Kaniber, Stefan Lichtmannecker, Thorsten Reichert, Guenther Reithmaier, Fabrice Laussy, Ulrich Hoheneester

Symposium SYTS "Thermoelectric and Spincaloric Transport in Nanostructures"

SYTS 1.1	Wed	9:30–10:00	H1	**Transport in Old and New Thermoelectric Materials** — •David Singh
SYTS 1.2	Wed	10:00–10:30	H1	**Binary oxide structures as model systems for thermoelectric transport** — •Peter J. Klar, Christian Heiliger
SYTS 1.3	Wed	10:30–11:00	H1	**Functional oxides films: from single crystals to polycrystalline substrates** — •Wilfrid Prellier
SYTS 1.4	Wed	11:00–11:30	H1	**The Planar Nernst Effect and the Search for Thermal Spin Currents in Ferromagnetic Metals** — •Barry Zink
SYTS 1.5	Wed	11:30–12:00	H1	**Tunneling magneto thermopower in magnetic tunnel junction nanopillars** — Niklas Liebing, Santiago Serrano-Guisan, Patryk Krzysteczko, Karsten Rott, Günter Reiss, Jürgen Langer, Berthold Ocker, •Hans Werner Schumacher

Symposium SYPM "Photons for Magnetism"

SYPM 1.1	Thu	15:00–15:30	H1	**Ultrafast emergence of nanoscale ferromagnetism far from equilibrium** — •Hermann Dürr
SYPM 1.2	Thu	15:30–16:00	H1	**Free-Electron Laser for Ultrafast Measurements in Material Science** — •Sven Reiche
SYPM 1.3	Thu	16:00–16:30	H1	**Nanomagnetism seen by Femtosecond X-rays** — •Stefan Eisebitt
SYPM 1.4	Thu	16:30–17:00	H1	**Ultrashort Radiation Pulses at Storage Rings** — •Holger Huck
SYPM 1.5	Thu	17:00–17:30	H1	**Every atom counts - Magnetic properties of supported metal atoms and small alloy clusters** — Torben Beeck, Ivan Baev, Steffen Palutke, Kai Chen, Sören Meyer, Kari Jänkälä, Michael Martins, •Wilfried Wurth

Symposium SYES "Frontiers of Electronic Structure Theory: Discovery of Novel Functional Materials"

SYES 1.1	Fri	9:30–10:00	H1	**Molecular dynamics simulation of nucleation and growth of crystals from solution** — •Michele Parrinello
SYES 1.2	Fri	10:00–10:30	H1	**Describing, understanding, and discovering hybrid materials from first principles** — •Claudia Draxl
SYES 1.3	Fri	10:30–11:00	H1	**Mapping the Electronic Structure Landscape for Materials Discovery** — •Krishna Rajan
SYES 1.4	Fri	11:00–11:30	H1	**New ferroelectrics and antiferroelectrics by design** — •Karin Rabe
SYES 1.5	Fri	11:30–12:00	H1	**The Materials Project: The design of materials using high-throughput ab initio computations** — •Gerbrand Ceder

Sessions

MA 1.1–1.2	Sun	16:00–18:00	H10	**Tutorial: Spindynamics and Spintransport**

MA 2.1–2.10	Mon	9:30–12:00	H3	**Multiferroics 1 (jointly wth DF,DS,KR,TT)**
MA 3.1–3.13	Mon	15:00–18:30	H3	**Multiferroics 2 (jointly wth DF,DS,KR,TT)**
MA 4.1–4.4	Mon	9:30–10:45	H10	**Topological Insulators 1 (jointly with DS,HL,O,TT)**
MA 5.1–5.10	Mon	15:00–18:00	H10	**Topological Insulators 2 (jointly with DS,HL,O,TT)**
MA 6.1–6.5	Mon	15:00–17:45	H20	**Focused Session: Correlations in Topological Bands (jointly with DS, HL, MA, and O)**
MA 7.1–7.5	Mon	9:30–11:15	H22	**Magnetic Particles in Biomedical Diagnostics and Therapy (jointly with BP,CPP,ST)**
MA 8.1–8.11	Mon	9:30–12:30	H23	**Spin Excitations and Spin Torque**
MA 9.1–9.14	Mon	15:00–18:45	H22	**Spincaloric Transport (jointly with TT)**
MA 10.1–10.5	Mon	15:00–17:30	H23	**Focus Session: Magnetic Excitations: from surfaces down to adatoms (jointly with O)**
MA 11.1–11.4	Mon	12:15–13:55	H3	**ThyssenKrupp Electrical Steel Dissertationspreis 2013 der AG Magnetismus**
MA 12.1–12.5	Tue	9:30–12:00	H10	**Focus Session: Terahertz Spintronics**
MA 13.1–13.12	Tue	9:30–12:45	H17	**Graphene - Electronic Properties and Transport 2 (jointly with DS, HL, MA, and O)**
MA 14.1–14.10	Tue	9:30–12:00	H23	**Micromagetic Simulation and Electron Theory of Magnetism**
MA 15.1–15.10	Tue	9:30–12:00	H3	**Spintronics and Magnetic Semiconductors (jointly with HL)**
MA 16.1–16.85	Tue	10:30–13:30	Poster D	**Poster I**
MA 17.1–17.11	Tue	9:30–13:00	H22	**Magnetic Particles and Clusters (jointly with CPP, BP)**
MA 18.1–18.9	Tue	9:30–13:45	H16	**Topological Defects in Magnetic Materials: from Devices to Cosmos (PhD-Student Symposium jointly with jDPG)**
MA 19.1–19.11	Tue	10:30–13:15	H33	**Surface and Interface Magnetism I (jointly with O)**
MA 20.1–20.13	Wed	9:30–13:00	H17	**Graphene: Characterization and devices (HL, jointly with DS, MA, O, TT)**
MA 21.1–21.5	Wed	9:30–12:00	H1	**Thermoelectric and Spincaloric Transport in Nanostructures**
MA 22.1–22.12	Wed	9:30–12:45	H2	**Transport: Molecular Electronics (jointly with CPP, HL, and MA)**
MA 23.1–23.10	Wed	9:30–12:15	H23	**Spin Effects in Molecules at Surfaces (jointly with DS,O)**
MA 24.1–24.11	Wed	9:30–12:15	H22	**Magnetic Imaging and Scattering Techniques**
MA 25.1–25.12	Wed	9:30–12:30	H10	**Magnetic Heusler Compounds**
MA 26.1–26.10	Wed	9:30–12:15	H3	**Magnetic Thin Films I of 2**
MA 27.1–27.10	Wed	15:00–17:45	H3	**Magnetic Thin Films II of 2**
MA 28.1–28.11	Wed	15:00–18:00	H22	**Magnetic Materials**
MA 29.1–29.11	Wed	15:00–18:00	H23	**Micro- and Nanostructured Magnetic Materials**
MA 30.1–30.6	Wed	15:00–18:00	H20	**Focused Session: Majorana Fermions in Condensed Matter (jointly with DS, HL, MA, and O)**
MA 31.1–31.5	Wed	15:00–17:30	H10	**Focus Session: Magnetic Damping Phenomena in Thin Films and Nanostructures (jointly with DS)**
MA 32.1–32.5	Thu	9:30–12:00	H10	**Focus Session: Spin Current Devices**
MA 33.1–33.10	Thu	9:30–12:00	H22	**Magnetization Dynamics I of 3**
MA 34.1–34.10	Thu	10:30–13:00	H33	**Surface and Interface Magnetism II (jointly with O)**
MA 35.1–35.9	Thu	9:30–11:45	H23	**Magnetic Oxides and Shape Memory Alloys (jointly with MM)**
MA 36.1–36.7	Thu	9:30–11:30	H3	**Magnetic Measurement Techniques**
MA 37.1–37.9	Thu	9:30–13:30	H32	**Focus Session: Organic Materials for Spintronics: From Spinterface to Devices (jointly with HL, MA, O)**
MA 38.1–38.13	Thu	9:30–13:00	H18	**Transport: Spintronics, Magnetotransport 1 (jointly with HL&MA)**
MA 39.1–39.7	Thu	9:30–12:45	H20	**Focused Session: Magnetism & Superconductivity in Fe-based Pnictides and Chalcogenides (jointly with MA)**
MA 40.1–40.8	Thu	15:00–17:15	H23	**Molecular Magnetism**
MA 41.1–41.10	Thu	15:00–18:00	H18	**Topological Insulators 4 (jointly with DS, HL, MA, and O)**
MA 42.1–42.5	Thu	15:00–17:45	H20	**Focus Session: Dynamical Mean-Field Approach to Correlated Electron Materials (jointly with MA)**
MA 43.1–43.11	Thu	15:00–17:45	H22	**Magnetization Dynamics II of 3**
MA 44.1–44.13	Thu	15:00–18:45	H3	**Surface Magnetism (jointly with O)**
MA 45.1–45.14	Thu	15:00–18:45	H10	**Magnetic Coupling and Spin Structures**
MA 46.1–46.13	Fri	9:30–13:00	H18	**Topological Insulators 5 (jointly with DS, HL, MA, and O)**
MA 47.1–47.4	Fri	9:30–10:30	H20	**Transport: Spintronics, Magnetotransport 2 (jointly with HL&MA)**

MA 48.1–48.12	Fri	9:30–12:45	H23	**Spin-dependent Transport Phenomena**
MA 49.1–49.10	Fri	9:30–12:00	H22	**Magnetization Dynamics III of 3**
MA 50.1–50.82	Fri	10:30–13:30	Poster D	**Poster II**

General Meeting of the Magnetism Section (Fachverband Magnetismus)

Wednesday 18:15–19:30 H10

All members of the Magnetism Section are invited to participate!

MA 1: Tutorial: Spindynamics and Spintransport

Time: Sunday 16:00–18:00 Location: H10

Tutorial MA 1.1 Sun 16:00 H10

Spindynamics and Spintransport — •Jürgen Lindner — Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, D-01314 Dresden

The first part of this tutorial focusses on the dynamic response of spin systems to time-dependent driving fields. The experimental method discussed in this context is magnetic resonance. It gives insight into key parameters like magnetic anisotropy, the g-factor, magnetic relaxation, spinwave excitations and magnetic coupling. The experimental setups used to detect magnetic resonance are moreover suitable to be included into many environments like ultrahigh vacuum or to be employed for investigations of nowadays magnetic nanostructures. Examples are given how magnetic resonance is used to study ultrathin films, interlayer coupling, ensembles of magnetic nanoparticles and also single nanostructures.

Tutorial MA 1.2 Sun 17:00 H10

Spindynamics and Spintransport — •Alina Deac — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The second part of the tutorial will discuss how spin-polarized currents can be used to excite magnetization dynamics and what applications can be envisioned. The spin-transfer torque arises from a transfer of angular momentum between the spin-polarized current and the magnetization and is sufficiently large to induce either reversal or steady-state precession. Magnetization switching via the spin-transfer torque effect relies on a constant current density, and thus the total current and the power consumption scale down with the lateral size of the device, thereby fulfilling the requirements for Green-Information-Communication Technology components. Spin-transfer driven precession generates output signals with GHz frequencies, which can be tuned by changing the applied current. Based on this effect, efficient frequency-tuneable microwave sources and resonators, nanometer scale transmitters and receivers, signal mixers and signal amplifiers can be designed. These devices could be used for mobile phone applications, on-chip communication, smart cards or even for microwave-assisted recording for hard-disk write heads.

MA 2: Multiferroics 1 (jointly wth DF,DS,KR,TT)

Time: Monday 9:30–12:00 Location: H3

MA 2.1 Mon 9:30 H3

Magnetoelectric coupling at the n-doped interface $BaTiO_3/SrTcO_3$ studied from first principles — •Vladislav Borisov[1], Sergey Ostanin[1], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

Antiferromagnetically induced magnetoelectric coupling at the interface $BaTiO_3/SrTcO_3$, which combines a robust ferroelectric and a stable antiferromagnetic perovskite, is studied from first principles. For the BaO/TcO_2-terminated interface, the magnetic order may change from G- to C-type antiferromagnetism upon the electric polarization reversal in the ferroelectric side. By inspecting the two-dimensional band structure and orbital occupation of the Tc 4*d*-states we conclude that the polarization-dependent charge transfer is responsible for a two-dimensional electron gas at the interface between two insulating perovskites. The case of paraelectric $BaTiO_3$ is also discussed in the context of the effect.

MA 2.2 Mon 9:45 H3

Observation of novel multiferroic-like effect in C60-Co nanocomposites — •Masashi Shiraishi[1], Eiiti Tamura[1], Yutaka Sakai[1], Toyokawa Shuhei[1], Eiji Shikoh[1], Vlado Lazarov[2], Atsufumi Hirohata[3], Teruya Shinjo[1], and Yoshishige Suzuki[1] — [1]Graduate School of Engineering Science, Osaka Univ., Japan — [2]Department of Physics, Univ. York, UK — [3]Department of Electronics, Univ. York, UK

A novel magnetoelectric effect is found to appear in a C60-Co nanocomposite. Although Co is well-known as a ferromagnet, its nanoparticles embedded in a C60 matrix can exhibit enhancement of magnetoresistance ratio due to a combination of Coulomb-blockade and higher order co-tunneling [1], and also multiferroic-like behavior [2], i.e., an electric field controls magnetic alignment of the nanoparticles and a magnetic field controls their charged states. This novel effect enables a strong magnetic switching effect for which the on/off ratio is ca. 1e4. Such an effect has been expected to exist and these findings show this magnetoelectric coupling for the first time.

[1] D. Hanataka, M. Shiraishi et al., Phys. Rev. B79, 235402 (2009). [2] Y. Sakai, E. Tamura, M. Shiraishi et al., Adv. Func. Mat. 22, 3845 (2012).

MA 2.3 Mon 10:00 H3

Investigation of magnetic ordering in $Eu_{1-x}Y_xMnO_3$ using full polarization analysis at P09 beamline — •Arvid Skaugen, Dinesh K. Shukla, Helen Walker, Sonia Francoual, and Jörg Strempfer — Deutsches Elektronen-Synchrotron, Harmburg, Germany

Varying multiferroic properties with strong ME coupling have been reported for $Eu_{1-x}Y_xMnO_3$ [1]. The crystal structure of $Eu_{1-x}Y_xMnO_3$ is similar to the one of $TbMnO_3$ with comparable lattice distortions. However, the effect of rare earth magnetism is eliminated since Eu^{3+} ($4f^6$) and Y^{3+} ($4f^0$) ions both are non-magnetic. The compound $Eu_{0.8}Y_{0.2}MnO_3$ first shows a phase transition at T_N = 45K from a paramagnetic to an antiferromagnetic and paraelectric state with a presumably sinusoidal collinear AFM structure, in analogy to $TbMnO_3$. At T_C = 30K the magnetic structure changes to weak ferromagnetism, attributed to a cone-like structure that breaks inversion symmetry and gives rise to ferroelectricity with the polarization along the a-axis.

We have investigated $Eu_{0.8}Y_{0.2}MnO_3$ using resonant x-ray diffraction as function of temperature, magnetic field and incident polarization at beamline P09 at PETRA III. The method of full polarization analysis has been used to investigate the different resonances showing up at the Mn K-edge. From the polarization scans, it is possible to draw conclusions on the complex magnetic order. Preliminary results suggest a helicoidal SDW structure of the Mn moments rather than a cone-like structure.

[1] J. Hemberger et al., Phys. Rev. B 75, 035118 (2007)

MA 2.4 Mon 10:15 H3

Electrostatic tuning of large-distance sputtered LSMO/PZT heterostructures — •Philipp Moritz Leufke, Ajay Kumar Mishra, Wang Di, Robert Kruk, and Horst Hahn — Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

In order to obtain a physical picture and quantitative characteristics of a magnetoelectric coupling at ferromagnetic/ferroelectric interfaces, epitaxial $La_{0.87}Sr_{0.13}MnO_3/Pb(Zr,Ti)O_3$ (LSMO/PZT) heterostructures were deposited by large-distance magnetron sputtering[1,2]. The remarkably high lateral uniformity achieved in such films allowed for a ferroelectric device area of more than 6 mm^2.

This has enabled for the first time *in-situ* SQUID measurements of the magnetic response to the systematically varied remanent ferroelectric polarization. Temperature dependence of the magnetic modulation upon charging and the magnetic response to the ferroelectric stimulation indicates a field-effect dominated coupling mechanism and generally confirms the concept of electrostatic hole (h^+) doping of LSMO.

For small charge modulations at low temperature, a linear tuning coefficient of $\approx 3.6\,\mu_B/h^+$ has been determined. This suggests the activation of an antiferromagnetic coupling, even for very small surface charge densities. Simultaneously a shift in the magnetic transition temperature at higher surface charge concentration indicates the presence of a ferromagnetic phase at the LSMO/PZT interface.

[1] P. M. Leufke *et al.*, *Thin Solid Films* **520**, 5521 (2012).
[2] P. M. Leufke *et al.*, *AIP Advances* **2**, 032184 (2012).

MA 2.5 Mon 10:30 H3

Optimized magnetoelectric interface coupling — •Igor Maznichenko[1], Arthur Ernst[2], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle (Saale), Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle (Saale), Germany

It was shown that magnetoelectric coupling occurs at interfaces between a magnetic and a ferroelectric material. Our idea is to construct heterostructures with a particularly strong magnetoelectric coupling. We concentrate on the optimization of the magnetic layer. We demonstrate that a small magnetic moment at the interface can still transfer the magnetoelectric coupling to a strong ferromagnet and could cause significant response. The idea is supported by numerical simulations within density functional theory using the self-consistent KKR Green function method.

MA 2.6 Mon 10:45 H3

Role of electron correlation of FeO at Fe/ferroelectric oxide/Fe interface for magnetic transport properties — •Andrea Neroni, Daniel Wortmann, Ersoy Sasioglu, Stefan Blügel, and Marjana Ležaić — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Fe/ferroelectric oxide/Fe is a nanoferronic tunnel junction with exciting electronic magneto-conductive transport properties. FeO layers at the interface of Fe/oxide/Fe barriers seems to significantly alter these properties as indicated by several experiments. In order to understand the role of electron correlations in FeO at the interface on the tunneling properties of a $Fe/BaTiO_3/Fe$ barrier we use an embedded Green-function approach [1] implemented within the framework of the full-potential linearized augmented plane-wave (FLAPW) method `FLEUR` [2]. Conductances are obtained for different oxidation conditions and for different magnetic configurations of the contacts. Strong correlations are taken into account employing the LDA+U approach within the framework of the density functional theory (DFT) with a Hubbard U parameter determined by constrained random phase approximation (cRPA) [3]. Work is supported by Helmholtz Young Investigators Group Program VH-NG-409.
[1] www.flapw.de
[2] D. Wortmann, H. Ishida, and S. Blügel, PRB **65**, 165103 (2002)
[3] E. Şaşıoğlu, C. Friedrich, and S. Blügel, PRB **83**, 121101(R) (2011)

MA 2.7 Mon 11:00 H3

Multiferroic Aurivillius Phases: the Case of $Bi_5FeTi_3O_{15}$ by *ab initio* — •Yael Birenbaum, Nicola Spaldin, and Claude Ederer — Materials Theory, ETH Zürich, Switzerland

The Aurivillius phases form a family of naturally-layered perovskite-related materials with good ferroelectric properties. $Bi_5FeTi_3O_{15}$ (BFTO) is perhaps the simplest known member of this family that also incorporates magnetic degrees of freedom. Using *ab initio* electronic structure calculations, we establish the ferroelectric and magnetic properties of BFTO. We then discuss a possible site preference of the Fe^{3+} cation, which so far has not been found experimentally, and quantify the magnetic coupling between adjacent Fe cations. In addition, we analyse the different structural distortions, in order to relate BFTO to other members of the Aurivillius phases.

MA 2.8 Mon 11:15 H3

Strain effect on magnetic properties of $La_{0.7}Ca_{0.3}MnO_3/SrRuO_3$ Superlattices — •Sujit Das[1,2], Andreas Herklotz[1,2], and Kathrin Doerr[1,2] — [1]IFW Dresden, Postfach 270116, 01171 Dresden, Germany — [2]Institute for Physics, MLU Halle-Wittenberg, 06099 Halle, Germany

Coherent interfaces between magnetic oxides such as $La_{0.7}$ $Sr_{0.3}MnO_3$ and $SrRuO_3$ may induce an intense magnetic coupling [1]. Recent work indicated an impact of elastic strain on the strength and even the sign of the coupling [2]. Superlattices (SL) of $La_{0.7}$ $Ca_{0.3}MnO_3/SrRuO_3$ with layer thicknesses below 10 unit cells were grown by pulse laser deposition simultaneously on $SrTiO_3$(001) (STO), $LaAlO_3$(001) (LAO) and piezoelectric $0.72Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.28PbTiO_3$ (001) (PMN-PT) substrates and structurally characterized by X-ray diffraction (XRD). On LAO, the SL assumes a compressive strain state, i. e. the lattice parameter is larger out-of-plane than in-plane, whereas on PMN-PT it shows a tensile strain state and on STO an intermediate strain value. Magnetization measurements demonstrate a strong antiferromagnetic (AFM) coupling in SLs on STO and LAO substrates which is due to superexchange interaction between Ru and Mn ions. The AFM coupling seems to decrease under tensile strain. The coupling is much weaker on PMN-PT, probably because of higher interface roughness. In order to probe the effect of elastic strain directly, magnetization loops in reversibly controlled strain states have been recorded for SLs on PMN-PT. [1] M. Ziese et al., PRL 104, 167203 (2010), [2] J. W. Seo et al., PRL 105, 167206 (2010) .

MA 2.9 Mon 11:30 H3

Tuning the multiferroic phase of CuO with impurities — •Johan Hellsvik[1], Marcello Balestieri[1], Alessandro Stroppa[2], Anders Bergman[3], Lars Bergqvist[4], Olle Eriksson[3], Silvia Picozzi[2], and José Lorenzana[1] — [1]ISC-CNR, Rome, Italy — [2]CNR-SPIN, L'Aquila, Italy — [3]Uppsala University, Uppsala, Sweden — [4]KTH, Stockholm, Sweden

The discovery that CuO is a multiferroic with a high antiferromagnetic transition temperature of 230 K opened a possible route to room-temperature multiferroicity with a strong magnetoelectric coupling [1]. CuO belongs [2] to a new class of multiferroic materials where the so called 'order by disorder mechanism' [3] plays a crucial role. In this work we study the effect of different impurities on the phase diagram of CuO aiming at engineering the multiferroic properties. Extensive density functional theory (DFT) calculations were performed for a large number of fixed spin configurations in pure CuO and CuO doped with a small fraction of the Cu atoms substituted with the nonmagnetic elements Mg, Zn or Cd, or the magnetic elements Ni or Co. Our computations established that the energy difference between the low-temperature collinear AF1 phase and the intermediate temperature multiferroic AF2 phase decreased monotonously with increasing doping level confirming that impurities favour the multiferroic phase. The magnetic phase diagram has been mapped out in Monte Carlo simulations for classical Heisenberg spins. [1] T. Kimura et al., Nature Mat. 7, 291 (2008); [2] G. Giovannetti et al., Phys. Rev. Lett. 106, 026401 (2011); [3] C. L. Henley, Phys. Rev. Lett. 62, 2056 (1989)

MA 2.10 Mon 11:45 H3

Charge-mediated magnetoelectric coupling in patterned multiferroic heterostructures — •daniele preziosi[1], dietrich hesse[1], marin alexe[1], martin wahler[2], and georg schmidt[2] — [1]Max-Planck-Institut für Mikrostrukturphysik Weinberg 2, 06120 Halle(Saale) Germany — [2]Martin-Luther-Universität Halle-Wittenberg Von-Danckelman-Platz 3, 06120 Halle(Saale) Germany

Several studies on single phase multiferroics demonstrate that the coupling between the ferroelectric and the (ferro)magnetic order parameters tends to be small. Engineering of artificially structured systems could provide a reliable way to improve the MagnetoElectric (ME) coupling. Devices based on charge-mediated ME effect represent a viable alternative. The electric field produced by the polarization of the ferroelectric material can induce, at the interface with an ultrathin strongly correlated magnetic oxide, a change in the magnetization. The ME coupling would be in this case the consequence of the spin-dependent screening of the electric field. Patterned hetero-structures of La1-xSrxMnO3 (LSMO) and PbZr0.2Ti0.8O3 (PZT) have been fabricated. Transport and magnetic measurements show that the switching of the PZT polarization influences significantly the competing electronic ground states of the LSMO, modulating the resistivity as well as the magnetization value.

MA 3: Multiferroics 2 (jointly wth DF,DS,KR,TT)

Time: Monday 15:00–18:30 Location: H3

MA 3.1 Mon 15:00 H3

Magnetization control in thin two-phase multiferroic structures via external electric fields — •Alexander Sukhov[1], Paul P. Horley[2], Chenglong Jia[3], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06120 Halle/Saale, Germany — [2]Centro de Investigation en Materiales Avanzados, S.C. (CIMAV), 31109 Chihuahua, Mexico — [3]Key Laboratory for Magnetism and Magnetic Materials of the Ministry of Education, Lanzhou University, Lanzhou 730000, China

We present a theoretical study of the coupled magnetization and polarization dynamics in a thin multiferroic junction related to a $BaTiO_3$ (rhombohedral phase) layer in contact with Fe-layer. The dynamical properties are discussed in the context of different interfacial magnetoelectric coupling mechanisms. For the magnetoelectric coupling induced by the screening of the spin-polarized electrons in Fe we investigate the minimum strength of the coupling constant which is required for the full switching of the magnetization [1]. In the case of a strain-induced magnetoelectric interaction we show an electric field-induced magnetic switching in the plane perpendicular to the magneto-crystalline easy axis while the total magnetization remains stable [2]. In addition, the response of the multiferroic structure to magnetic radio-frequency fields by means of ferromagnetic resonance and dependent on the applied electric field is studied. [1] P.P. Horley, A. Sukhov, C.-L. Jia, E. Martinez, J. Berakdar, Phys. Rev. B **85**, 054401 (2012). [2] C.-L. Jia, A. Sukhov, P.P. Horley, J. Berakdar, Europhys. Lett. **99**, 17004 (2012).

MA 3.2 Mon 15:15 H3

Magnetic field induced charge anisotropy in $CoFe_2O_4/BaTiO_3$ nanocomposite — •Carolin Schmitz-Antoniak[1], Detlef Schmitz[2], Sven Stienen[1], Pavel Borisov[3], Anne Warland[1], Bernhard Krumme[1], Wolfgang Kleemann[1], and Heiko Wende[1] — [1]Fakultät für Physik, Universität Duisburg-Essen, D-47048 Duisburg — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, D-12489 Berlin — [3]Department of Chemistry, University of Liverpool, Liverpool L69 7ZD

The system of $CoFe_2O_4$ nanopillars in a $BaTiO_3$ matrix represents a multiferroic nanocomposite in which strong ferrimagnetism and strong ferroelectricity coexist at room temperature [1]. The magnetostrictive CFO nanopillars and the piezoelectric BTO matrix are coupled by strain so that it is possible to change the electric properties by a magnetic field and the magnetic properties by an electric field. The charge anisotropy of Ti ions is probed by x-ray linear dichroism (XLD) and the magnetisation of Co ions by x-ray magnetic circular dichroism (XMCD) giving the unique possibility to study the effect of the coupling on a microscopic level as a function of magnetic field strength and direction. The occurrence of significant in-plane components of the electric polarisation is discussed. They are due to shear forces acting on the $BaTiO_3$ matrix while taking into account non-diagonal piezoelectricity components.

Funded by DFG (SFB491) and BMBF (05 ES3XBA/5).

[1] H. Zheng et al., Science 303, 661 (2004)

MA 3.3 Mon 15:30 H3

Multiferroic CoFe2O4/ BaTiO3 with core shell structure nanoparticles — •Morad Etier[1], Vladimir V.Shvartsman[1], Yanling Gao[1], Joachim Landers[2], Heiko Wende[2], and Doru C.Lupascu[1] — [1]University of Duisburg-Essen, Institute for Materials Science, Essen, Germany — [2]University of Duisburg-Essen, Faculty of Physics, Duisburg, Germany

Multiferroic materials exhibit ferroelectricity and ferromagnetism simultaneously. Combining piezoelectricity and magnetostriction components in the same composite received more interests in the modern researches. In this work we report synthesis and properties of cobalt iron oxide barium titanate composite with a core shell structure. To synthesize the samples we combine co-precipitation and organosol method. Phases content, microstructure and morphology were studied by x-ray diffraction, SEM and TEM. Multiferroic properties were proved by home-built Sawyer-Tower circuit and SQUID magnetometry. Temperature dependence of magnetic moment was measured in zero field cooling (ZFC) and field cooling (FC) and compared with those cobalt iron oxide nanopowder. The dielectric properties were studied using impedance spectroscopy.

MA 3.4 Mon 15:45 H3

Strain-induced changes of magnetic anisotropy in epitaxial spinel-type cobalt ferrite films — •Stefania Florina Rus[1,2], Andreas Herklotz[2,4], Iuliu Grozescu[3], and Kathrin Dörr[4] — [1]Politehnica University of Timişoara, 300006 Timişoara, Romania — [2]IFW Dresden, 01171 Dresden, Germany — [3]Institute for Research and Development in Electrochemistry and Condensed Matter, 300224 Timisoara, Romania — [4]Martin-Luther-Universität Halle-Wittenberg, Institute for Physics, 06099 Halle, Germany

We present results on the effect of biaxial strain on the magnetic anisotropy of thin films of the parent compound CoFe2O4 and films with a partial substitution of Co and Fe by Zr and Pt, respectively. The strain states of the epitaxially grown films are controlled twofold: (i) statically by epitaxial misfit strain via an appropriate choice of substrates and buffer layers and (ii) reversibly by strain transfer from piezoelectric $Pb(Mg_{1/3}Nb_{2/3})_{0.72}Ti_{0.28}O_3$ (001) (PMN-PT) substrates. Due to large negative magnetostriction all films show an out-of-plane magnetic easy axis under tensile strain and an in-plane easy axis under compressive strain. Our reversible strain measurements show that the magnetic anisotropy can be efficiently altered by the application of an electric field to the ferroelectric PMN-PT substrates. The effect of substitution with Zr and Pt on the magnetoelectric effect will be discussed. This work is supported by the strategic grant POSDRU ID77265 (2010), co-financed by the European Social Fund, within the Sectoral Operational Programme Human Resources Development 2007-2013. Advising by P. Vlazan is greatly acknowledged.

MA 3.5 Mon 16:00 H3

***Ab initio* study of magneto-phonon interaction in $GaFeO_3$** — •Konstantin Z. Rushchanskii, Stefan Blügel, and Marjana Ležaić — Peter Grünberg Institut, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Magnetoelectric (ME) coupling provides a handle for manipulating the magnetization of a material with an electric field, giving a perspective for a new type of non-volatile memory. Unfortunately, materials with ME coupling that is large enough for industrial applications are scarce. Moreover, among the materials which are both ferroelectric and magnetic at room temperature, only $BiFeO_3$ is known. Unfortunately, the ordering of spins in this material is antiferromagnetic (whereas ferro/ferrimagnetic coupling is desired) and the ME coupling is small.

$GaFeO_3$ (GFO) is the first material observed to simultaneously present a strong ME coupling and a resulting magnetization in a single phase. It has the polar structure $Pc2_1n$, which allows disorder in A and B cation sites. By increasing the iron content its Curie temperature can be increased above room temperature [1].

To understand the mechanism of the strong ME coupling in $GaFeO_3$ at the microscopic level, we performed *ab initio* calculations based on density functional theory of the structural properties and magneto-phonon interaction in stoichiometric $GaFeO_3$ compounds in different structures, as well as with different occupancies of the A and B sites.

We acknowledge the support by Helmholtz Young Investigators Group Programme VH-NG-409 and GALIMEO Consortium.

[1] T. Arima *et al.*, Phys. Rev. B **70**, 064426 (2006)

MA 3.6 Mon 16:15 H3

The effect of ion doping on multiferroic $MnWO_4$ — •safa golrokh bahoosh[1,3], julia m. wesselinowa[2], and steffen trimper[3] — [1]Max Planck Institute of Microstructure Physics,Weinberg 2, 06120 Halle, Germany — [2]University of Sofia, Department of Physics,Blvd. J. Bouchier 5, 1164 Sofia, Bulgaria — [3]Institute of Physics, Martin-Luther-University, 06120 Halle, Germany

We have studied the ion doping effects on different transition temperatures in the multiferroic compound $MnWO_4$ based on a microscopic model and within the framework of Green functions technique. It is shown that the exchange interaction constants can be changed due to the different ion doping radii. This leads to reduction of the magnetic phase transition temperature T_N by doping with non-magnetic ions,such as Zn, Mg, whereas T_N is enhanced by doping withtransition metal ions, such as Fe, Co. The different behavior of the temperature T_1 (where up-up-down-down collinear spin structure appears) by Fe

and Co doping could be explained taking into account the single-ion anisotropy.

15 min. break

MA 3.7 Mon 16:45 H3

Hybrid improper ferroelectricity in a Multiferroic and Magnetoelectric Metal- Organic Framework — •Alessandro Stroppa[1], Paolo Barone[1], Prashant Jain[2], Manuel Perez-Mato[3], and Silvia Picozzi[1] — [1]CNR-SPIN Via Vetoio, 67100, L'Aquila (Italy) — [2]Los Alamos National Lab, 30 Bikini Atoll Rd Los Alamos, NM 87545-0001 (505) 664-5265 — [3]Departamento de Fisica de la Materia Condensada, Facultad de Ciencia y Tecnologia, UPV/EHU, Bilbao (Spain)

Metal-organic frameworks (MOFs) show increasing promise as candidates for various applications. Of particular interest are MOFs with the perovskite topology showing hydrogen bonding-related multiferroic phenomena. By using state-of-the-art-ab-initio calculations, we show that in [C(NH2)3]Cr(HCOO)3 MOF, interaction between the cooperative antiferro-distortive Jahn-Teller distortions and the C(NH2)3 cations breaks the inversion symmetry through hydrogen-bonding and induces a ferroelectric polarization. Interestingly, the polar behavior arises due to a trilinear coupling between two unstable modes, namely a Jahn-Teller and a tilting mode, and one stable polar mode. Therefore, this compound represents the first example of hybrid improper ferroelectric in the family of metal-organic compounds. Since rotational modes in perovskite-inorganic compounds usually freeze-in at elevated temperatures (300 K), the trilinear coupling in MOF compounds may provide an interesting route to realize room temperature multiferroic. Last but not least, we show that switching of polarization direction implies the reversal of a large weak ferromagnetic component.

MA 3.8 Mon 17:00 H3

Ferroelectric properties of (Ba,Sr)TiO_3/$La_{0.7}Sr_{0.3}MnO_3$ multilayered thin films — •Markus Michelmann[1], Johannes Aprojanz[1,2], Arseni Buryakov[2], Elena Mishina[2], Markus Jungbauer[1], Sebastian Hühn[1], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]Moscow State Institute of Radioengineering, Electronics and Automation, Prosp. Vernadskogo 78, 119454 Moscow, Russia

$Ba_xSr_{1-x}TiO_3$ (BSTO) epitaxial thin films became feasible for room temperature applications in contrast to the bulk material due to a possibility to enhance the ferroelectric Curie temperature under biaxial compressive strain. Using $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) thin films as metallic electrodes, we have grown highly strained BSTO/LSMO bilayers and LSMO/BSTO/LSMO trilayers on $SrTiO_3$ (100) substrates with BSTO layer thicknesses of 10 - 200 nm by means of metalorganic aerosol deposition. Ferroelectric switching was studied both electrically and by nonlinear optics (second harmonic generation (SHG)). Capacitance-voltage characteristics in a frequency range of $f = 1-10^6$ Hz and PUND measurements prove a ferroelectric hysteretic behavior up to room temperature with a remanent polarization of several $\mu C/cm^2$ and a switching fields in the range of $10-100$ kV/cm. This was also supported by the SHG measurements. A detailed study of multiferroic properties will be performed for temperatures, $T = 10-400$ K, and applied magnetic field, $B = 0-9$ T. This work was supported by IFOX of the European Community's 7th Framework Programme.

MA 3.9 Mon 17:15 H3

Epitaxial thin films of the multiferroic double perovskite Bi_2FeCrO_6 — •Vikas Shabadi, Mehran Vafaee, Mehrdad BaghaieYazdi, Aldin Radetinac, Philipp Komissinskiy, and Lambert Alff — Institute of Materials Science, Technische Universität Darmstadt, Germany

Co-existence of magnetism and ferroelectricity was theoretically predicted in the ordered double perovskite Bi_2FeCrO_6 (BFCO) [1]. We report epitaxial BFCO thin films grown by pulsed laser deposition from a 20% Bi-rich ceramic target on single crystal $SrTiO_3$(100) substrates. The degree of the Fe-Cr cation ordering in the BFCO films was calculated based on the X-ray diffraction patterns. The magnetic moments of the BFCO films were measured with a SQUID magnetometer and analyzed as a function of the Fe-Cr ordering. The discrepancies in the previously reported values of the magnetic moment of BFCO [2,3] are most likely connected to the varying degree of the Fe-Cr cation ordering in the samples. In a recent experiment more than 90% spontaneous B-site ordering in a similar Fe-Cr based double perovskite system has been achieved [4]. Anti-site disorder control is a key challenge to design double perovskite multiferroics.

[1]P. Baettig and N. A. Spaldin, Appl. Phys. Lett. **86**, 012505 (2005)
[2]Kim *et al.*, Appl. Phys. Lett. 89, 102902 (2006)
[3]R. Nechache *et al.*, J. Appl. Phys. **105**, 061621 (2009)
[4]S. Chakraverty *et al.*, Phys. Rev. B **84**, 064436 (2011)
The authors acknowledge support from DAAD.

MA 3.10 Mon 17:30 H3

Growth of multiferroic heterostructures — •Sergiu Stratulat, Dietrich Hesse, and Marin Alexe — Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

Coupling two materials with different order parameters gives great flexibility in engineering multifunctional devices. In achieving the maximum interfacial effects, vertical heterostructures present the maximum potential. Creating well-ordered vertical multiferroic heterostructures is not a trivial task, especially on large areas. We are focusing our attention on the system comprising ferrimagnetic CoFe2O4 and ferroelectric/antiferromagnetic BiFeO3, using pulsed laser deposition as a synthesizing technique. Considering a time-viable process to create the pillar-matrix configuration, we used anodic aluminum oxide masks to pattern the nucleation sites for the cobalt ferrite on previously deposited SrRuO3 bottom electrode on SrTiO3. After removal of the mask, deposition by means of a mixed target leads to ordered arrays of CFO pillars embedded in a BFO matrix. Scanning electron microscopy was employed at every step of the experiments to show the development of the samples, and X-ray diffraction probed the structural parameters. Testing the ferroelectric and magnetic properties locally gives an indication on the coupling influences present in the thin films.

MA 3.11 Mon 17:45 H3

Self-assembled composite multiferroic films in controlled strain states — •Mohsin Rafique[1,2,3,4], Andreas Herklotz[3,4], Er-Jia Guo[3,4], Kathrin Doerr[3,4], and Sadia Manzoor[1,2] — [1]Magnetism Laboratory, COMSATS Institute of Information Technology, Park Road 44000, Islamabad, Pakistan — [2]Center for Micro and Nano Devices (CMND), COMSATS Institute of Information Technology, Park Road 44000, Islamabad, Pakistan — [3]IFW Dresden, Postfach 270116, 01171 Dresden, Germany — [4]Institute for Physics, Martin-Luther-University Halle-Wittenberg, 06099 Halle, Germany

Self-assembled thin-film nanocomposites of piezoelectric and magnetostrictive materials have stimulated increasing research activities because of their potential to exhibit a large magnetoelectric response exploitable in multifunctional devices. Epitaxial thin films of $CoFe_2O_4$ and $BaTiO_3$ (CFO-BTO) composites were grown on $SrTiO_3$ (001) and piezoelectric $Pb(Mg_{1/3}Nb_{2/3})_{0.72}Ti_{0.28}O_3$(001) (PMN-PT) substrates by pulsed laser deposition. Self-assembled nanostructures consisting of spinel nanopillars heteroepitaxially embedded in the ferroelectric perovskite matrix form. X-ray diffraction is utilized to estimate the lattice parameters. The magnetic properties studied by SQUID magnetometry show an out-of-plane easy axis of the CFO nanopillars and a strengthening of the out-of-plane anisotropy with increasing compression along the nanopillar axis. The magnetoelectric coupling in the composite film is revealed at a structural transition of the BTO matrix. Electrically controlled substrate strain of PMN-PT is applied to modify the magnetic anisotropy of the nanopillars.

MA 3.12 Mon 18:00 H3

Low-lying magnetic excitations in the distorted triangular lattice antiferromagnet α-$CaCr_2O_4$ — •Michael Schmidt[1], Zhe Wang[1], Sandor Toth[2], Bella Lake[2], A.T.M.Nazmul Islam[2], Alois Loidl[1], and Joachim Deisenhofer[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, D-14109 Berlin, Germany

We will discuss our results on α-$CaCr_2O_4$ obtained by FIR and Terahertz spectroscopy. This compound orders below $T_N = 42.6$ K in a proper screw 120° magnetic order, but shows additional low-lying magnetic modes indicative for the vicinity of a more complex magnetic order [1], [2]. Our spectra obtained by FTIR and THz-TD spectroscopy show several optical magnons appearing below the magnetic ordering with anomalous temperature dependence. We will discuss their polarization dependence and a possible magnetoelastic coupling

of these modes.

[1] S. Toth *et al.*, Phys. Rev. B 84, 054452 (2011)
[2] S. Toth *et al.*, PRL 109, 127203 (2012)

MA 3.13 Mon 18:15 H3

Multiferroic $Ni_3V_2O_8$ measured in THz range at low temperatures and in high magnetic fields — •Malte Langenbach[1], Tobias Hissen[1], Komalavalli Thirunavukkuarasu[1], Holger Schmitz[1], Iván Cámara Mayorga[2], Rolf Güsten[2], Joachim Hemberger[1], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln, Köln, Germany; — [2]Max-Planck-Institut für Radioastronomie, Bonn, Germany;

THz spectroscopy in high magnetic fields is an important technique to probe materials with strong magneto-electric coupling. Here, we discuss the Kagomé-staircase compound $Ni_3V_2O_8$. The triangle-based lattice gives rise to a frustration of the short-range antiferromagnetic couplings. This causes a rich variety of magnetic and structural phases at low temperatures.
Below $T_N = 9.8$ K, a incommensurate phase with collinear sinusoidal spin structure is established. This phase is followed by a cycloidal spin structure which is accompanied by the onset of ferroelectricity. Finally, below 3.9 K, the structure changes to a commensurate canted antiferromagnetic phase [1].
We report on elementary excitations in the THz range observed between 2 K and 50 K in fields up to 8 T.

Work supported by the DFG through SFB 608.

[1] G. Lawes et al., Phys. Rev. Lett. **95**, 087205 (2005)

MA 4: Topological Insulators 1 (jointly with DS,HL,O,TT)

Time: Monday 9:30–10:45 Location: H10

Invited Talk MA 4.1 Mon 9:30 H10

Breaking time reversal symmetry in topological insulators — •Jagadeesh Moodera — Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Breaking time reversal symmetry in a topological insulator (TI) can lead to many exotic properties, such as image magnetic monopole, topological magneto-electric effects as well as Majorana Fermions in superconducting TIs (STI). Recently Gedik*s group in MIT demonstrated that manipulating the magnetic properties via ultrashort light pulses, selectively exciting the spin states of the surface state by exploiting its spin texture to induce a transient magnetic state. Using linearly polarized light in a pump-probe experiment unusual behavior was seen by Muenzenberg group in Gottingen University. The TI surface state can be magnetically manipulated by proximity effect. The proximity-induced ferromagnetism in a TI/ferromagnetic insulator heterostructure breaks the time reversal symmetry in the TI: a large uniformly induced surface exchange gap appears on the TI without introducing scattering centers, thus keeping intact the transport of spin-momentum locked surface electrons as well as the superconducting pairing in an STI. This TI/ferromagnetic insulator bilayer system showed an induced interface magnetic moment accompanied by an unusual planar hysteresis magnetoresistance demonstrating the magnetic manipulation of the surface channel. This research is supported by ONR, NSF.

MA 4.2 Mon 10:00 H10

Magnetic properties of the Mn doped topological insulator Bi_2Te_3 probed by ESR — •S. Zimmermann[1], V. Kataev[1], Huiwen Ji[2], R.J. Cava[2], and B. Büchner[1] — [1]IFW Dresden, 01171 Dresden, Germany — [2]Dept. Chem., Princeton Univ., NJ 08544, USA

Doping of a topological insulator (TI) with magnetic elements can break the time reversal symmetry and thus open a gap in the protected spin polarized conducting surface states, driving the system into a quantum spin Hall regime [1]. Understanding of the interactions between localized magnetic moments of dopants via delocalized electrons that give rise to ferromagnetism in TIs is therefore of significant interest. Such interactions can be of a long-range character and can also be mediated by surface conducting states [2]. Electron Spin Resonance (ESR) spectroscopy is a sensitive local technique that can probe interactions of localized spins with conduction electrons as well as spin-spin interactions in semiconductors and metals. In this contribution we report an ESR study of the Mn spin dynamics and magnetic interactions in high-quality single crystals of the Mn doped 3-dimensional TI Bi_2Te_3 [3]. We have observed a well-defined ESR signal from Mn spins and have studied the temperature dependences of the ESR parameters for a set of Bi_2Te_3 crystals with different Mn doping levels. The experimental ESR data will be presented in detail and the doping dependence of the Mn spin relaxation via conducting states and the establishment of ferromagnetic order as seen by ESR will be discussed. [1] R. Yu et al., Science **369**, 61 (2010); [2] L.A. Wray et al., Nature Physics **7**, 32 (2011); [3] Y.S. Hor et al., PRB **81**, 195203 (2010)

MA 4.3 Mon 10:15 H10

Investigation of the relation between surface band gaps and magnetism in the magnetic topological insulator $(Bi_{1-x}Mn_x)_2Se_3$ — •Jaime Sánchez-Barriga[1], Andrei Varykhalov[1], Gunther Springholz[2], Hubert Steiner[2], Raimund Kirchschlager[2], Günther Bauer[2], Ondrei Caha[3], Enrico Schierle[1], Eugen Weschke[1], Akin Ünal[1], Sergio Valencia[1], Florian Kronast[1], and Oliver Rader[1] — [1]Helmholtz-Zentrum Berlin — [2]Johannes Kepler Universität Linz — [3]Masaryk University, Brno

The Dirac cone at the surface of a magnetic topological insulator is expected to open a band gap when ferromagnetically magnetized perpendicularly to the surface plane. Angle-resolved photoemission from epitaxial films of $(Bi_{1-x}Mn_x)_2Se_3$ shows for $x > 0.02$ a band gap at the Dirac point of a size that varies with Mn concentration, is much larger than theoretically predicted (~ 100 meV), and does not change with temperature from 7 to 300 K. Based on our measurements with x-ray magnetic circular dichroism (XMCD) we can exclude that the surface band gap is due to ferromagnetic order in the bulk or at the surface. In addition, we investigate by XMCD in photoemission microscopy the reported proximity magnetization induced by a ferromagnetic overlayer.

MA 4.4 Mon 10:30 H10

Mapping the influence of cobalt atoms on the topological states of Bi2Te3 — •Paolo Sessi, Thomas Bathon, Lydia El-Kareh, and Matthias Bode — Institute of Experimental Physics II, University Würzburg, Am Hubland, 97074 Würzburg

Topological insulators are characterized by linearly dispersing gapless topological surface states protected by time-reversal symmetry. For these states, spin is perpendicularly locked to its momentum by spin-orbit interaction resulting in a chiral spin structure that forbids backscattering. However, this is predicted to not be the case when magnetic impurities are introduced into the system. Here, by means of scanning tunneling microscopy we investigate the robustness of the surface states of Bi2Te3 when single Co atoms are deposited on the surface. By analyzing the energy dependence of the quasi particle interference pattern produced by coherent scattering of surface states, we will examine the influence of Co atoms on scattering channels and energy dispersion relation.

MA 5: Topological Insulators 2 (jointly with DS,HL,O,TT)

Time: Monday 15:00–18:00 Location: H10

Invited Talk MA 5.1 Mon 15:00 H10

The THz response of topological insulator surface states — •N. Peter Armitage — The Institute of Quantum Matter, Department of Physics and Astronomy, Johns Hopkins University, Baltimore, MD 21218, USA

Topological insulators (TIs) are newly discovered states of matter characterized by an *inverted* band structure driven by strong spin-orbit coupling. One of their most touted properties is the existence of robust "topologically protected" surface states. I will discuss what topological protection means for transport experiments and how it can be probed using the technique of time-domain THz spectroscopy applied to thin films of Bi_2Se_3. By measuring the low frequency optical response, we can follow their transport lifetimes as we drive these materials through instabilities either by doping through a quantum phase transition into a topologically trivial regime or by reducing the film thickness. I'll also discuss our work on the magnetic field dependence of the Kerr rotation in Bi_2Se_3, where we find an unprecedentedly large value of the angle of rotation of reflected light, which is due to the cyclotron resonance of the 2D Dirac fermions.

15 min. break

MA 5.2 Mon 15:45 H10

Peierls dimerization at the edge of 2D topological insulators? — •Gustav Bihlmayer[1], Hyun-Jung Kim[2], Jun-Hyung Cho[2], and Stefan Blügel[1] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany — [2]Department of Physics and Research Institute for Natural Sciences, Hanyang University, Seoul, Republic of Korea

Edge states of two-dimensional topological insulators (2D-TIs) attracted considerable interest as they support dissipationless spin-currents. Recently, it was proposed that the zigzag-edge of a Bi(111) bilayer, identified as a 2D-TI [1,2], is unstable with respect to a Peierls dimerization [3], a phenomenon that occurs quite general in one-dimensional structures. This proposal was based on an *ab initio* investigation without taking spin-orbit coupling (SOC) into account. We investigate the effect of SOC on the atomic structure of zigzag Bi(111) and Sb(111) nanoribbons. Although we find that edge-reconstructions can influence the number of conductive channels, we conclude that the topological protection of the states in the Bi ribbon actually prevents the Peierls mechanism to get effective, since the opening of a Peierls gap at the zone boundary is forbidden by time-reversal symmetry. We compare the situation to the Sb structure, but also in the topologically trivial case of the Sb(111) bilayer ribbon we find a suppression of the dimerization due to SOC effects.

[1] S. Murakami, Phys. Rev. Lett. 97, 236805 (2006) [2] M. Wada et al., Phys. Rev. B 83, 121310(R) (2011) [3] L. Zhu et al., J. Phys. Chem. C 114, 19289 (2010)

MA 5.3 Mon 16:00 H10

Engineering quantum anomalous Hall (QAH) phases with orbital and spin degrees of freedom — •Hongbin Zhang, Frank Freimuth, Gustav Bihlmayer, Marjana Ležaić, Stefan Blügel, and Yuriy Mokrovsov — Peter Grünberg Institut and Institute for Advanced Simulation, FZJ and JARA, 52425 Jülich, Germany

Combining tight-binding models and first-principles calculations, we demonstrate that under external exchange fields, non-zero Chern numbers and nontrivial QAH effects can be induced by on-site spin-orbit coupling (SOC) in buckled honeycomb lattices with *sp* orbitals. In the Haldane model [1], the occurrence of the QAH effect is attributed to complex valued next-nearest-neighbor hopping matrix elements. Detailed analysis of a generic tight binding model reveals that there exist different mechanisms giving rise to complex hoppings, utilising both orbital and spin degrees of freedom of electrons on a lattice. Furthermore, it is shown that in Bi- or Sb(111) bilayers [2], different topological phases exist as function of the magnitude of SOC and external exchange fields. These phases are characterised using Chern and spin Chern numbers [3] in combination with transverse charge and spin conductivities. At last, we show that introducing ferromagnetic dopants provides a practical way to induce nontrivial topological phases, whereas the physics is altered due to partially filled *d* states around the Fermi energy. – Support by Helmholtz Young Investigators Group Programmes VH-NG-409 and -513 is acknowledged.

[1] F.D.M. Haldane, PRL **61**, 2015 (1988). [2] H. Zhang, *et al.*, PRB **86**, 035104 (2012). [3] E. Prodan, PRB **83**, 195119 (2011).

MA 5.4 Mon 16:15 H10

Prediction of weak topological insulators in layered semiconductors — •Binghai Yan[1,2], Lukas Müchler[1,2], and Claudia Felser[1,2] — [1]Max Planck Institute for Chemical Physics of Solids, D-01187 Dresden — [2]Institute for Inorganic and Analytical Chemistry, Johannes Gutenberg University of Mainz, 55099 Mainz

We report the discovery of weak topological insulators by ab initio calculations in a honeycomb lattice. We propose a structure with an odd number of layers in the primitive unit cell as a prerequisite for forming weak topological insulators. Here, the single-layered KHgSb is the most suitable candidate for its large bulk energy gap of 0.24 eV. Its side surface hosts metallic surface states, forming two anisotropic Dirac cones. Although the stacking of even-layered structures leads to trivial insulators, the structures can host a quantum spin Hall layer with a large bulk gap, if an additional single layer exists as a stacking fault in the crystal. The reported honeycomb compounds can serve as prototypes to aid in the finding of new weak topological insulators in layered small-gap semiconductors.

MA 5.5 Mon 16:30 H10

Dirac States in a Novel Topological Insulator: Epitaxial alpha-Tin Layers on Indium Antimonide — •J. Schäfer[1], A. Barfuss[1], G. Bihlmayer[2], D. Wortmann[2], L. Dudy[1], P. Höpfner[1], A. Bostwick[3], E. Rotenberg[3], and R. Claessen[1] — [1]Phys. Inst., Universität Würzburg, D — [2]Peter Grünberg Inst. and Inst. Adv. Sim., FZ Jülich, D — [3]Lawrence Berkeley Nat. Lab., USA

This study addresses a new material realization of a topological insulator (TI) thus far only proposed theoretically, which is formed by α-Sn in the diamond lattice on InSb substrates. The epitaxial growth opens various pathways to access and manipulate the topological surface state (TSS). This includes the evolution of the Dirac bands as a function of thickness, or surface coating layers which alter the spin-orbit interaction. Interestingly, the TI band properties are closely related to that of strained HgTe, for which the Quantum Spin Hall effect was demonstrated.

Here we report on the electronic structure of α-Sn(001) based on angle-resolved photoemission (ARPES), complemented by density functional theory (DFT). We observe the formation of a clearly pronounced Dirac cone. The Fermi level in ARPES is located close to the Dirac point. Its position can be controlled by dopants, which allows to adjust the Fermi level crossings of the TSS. The Dirac cone is discernible down to bulk band energies, and its constant energy surfaces seemingly reflect the lattice symmetry. The experimental findings are consistent with DFT calculations including spin-orbit interaction, which document the formation of a TSS.

MA 5.6 Mon 16:45 H10

Observation of terahertz photocurrents in the topological insulator Bi_2Se_3 — •Lukas Braun[1], Luca Perfetti[2], Martin Wolf[1], and Tobias Kampfrath[1] — [1]Physikalische Chemie, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Laboratoire des Solides Irradiés, Ecole Polytechnique, Palaiseau cedex, France

Recent experiments have indicated that optical excitation of topological insulators (TIs) with circularly polarized light can induce spin-polarized electron currents along the TI surface. The direction of this photocurrent can be controlled by varying the circular polarization of the driving light from right- to left-handed. So far, only DC photocurrents have been detected [J. W. McIver *et al.* Nature Nanotechnology **7**, 96 (2012)]. Since electrons moving through a solid typically undergo scattering on sub-picosecond time scales, it is highly desirable to generate and detect TI photocurrents with femtosecond time resolution.

Here, we drive ultrashort current bursts in n-doped Bi_2Se_3 by excitation with a laser pulse (10fs, 800nm, 10nJ). The photocurrent gives rise to the emission of a terahertz (THz) electromagnetic pulse whose transient electric field $E(t)$ is detected by means of electro-optic sampling with a time resolution of 10fs. We observe extremely broadband THz emission covering the range from 10 to 30THz, and the THz in-

tensity is found to depend strongly on the helicity of the pump pulses. A method is presented that allows us to extract the transient current $j(t)$ from the measured $E(t)$. We finally discuss the origin of $j(t)$ and implications for the dynamics of photoexcited TI electrons.

MA 5.7 Mon 17:00 H10

Static screening properties of topologically protected surface states — •Daniel Wortmann, Gustav Bihlmayer, Yuriy Mokrousov, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The electrons occupying surface states of topological insulators (TI) provide charges that can screen electric fields applied perpendicular to the surface. Being a very basic phenomenon, its realistic description is rather difficult: model approaches fail to provide quantitative results while DFT calculations of insulating slabs with external electric fields suffer from difficulties arising from the incomplete screening of the field inside the slab.

We demonstrate that the embedded Green function method [1,2] can be utilized to investigate the effects of an applied field on the surface states. Our approach describes the formation of surface states in terms of their scattering properties at the semi-infinite bulk states by means of a generalized logarithmic derivative. Besides discussing the underlying idea of this elegant theoretical tool and its application to prototypical topological insulators, we present a comparison of the expected screening effects seen in a topological insulator with those in a topological material.

[1] see http://www.flapw.de for details of the code

[2] D. Wortmann, H. Ishida, S. Blügel, Phys. Rev. B **65**, 165103 ('02)

MA 5.8 Mon 17:15 H10

Topological phases of spin chains — Kasper Duivenvoorden and •Thomas Quella — Universität zu Köln, Institut für Theoretische Physik, Köln, Deutschland

The Haldane phase of one-dimensional $S = 1$ spin chains with $SU(2)$ symmetry is one of the first topological states of matter. In particular, it features a bulk-boundary correspondence, with $S = 1/2$ degrees of freedom emerging at the boundaries of the system. Moreover, it exhibits a diluted anti-ferromagnetic order which can be measured using a non-local string order parameter. With the prospect of being able to simulate spin chains with $SU(N)$ symmetry in the laboratory using ultracold earth-alkaline atoms it is a natural and interesting question whether similar topological phases also exist beyond $N = 2$.

In a recent paper we have shown that this is indeed the case. More precisely, spin chains with $SU(N)$ symmetry allow for up to N different topological phases, $N - 1$ of which are topologically non-trivial. These phases exhibit topological order that is reflected in a specific entanglement pattern resulting from the matrix product state representation of the corresponding ground state wave function. It may be detected using a non-local string order parameter which characterizes each of the N phases unambiguously. Analytical and numerical results confirm that our order parameter may be used to extract a quantized topological invariant.

MA 5.9 Mon 17:30 H10

Strongly-correlated topological semiconductors — •Stanislav Chadov[1], Claudia Felser[1], Leon Petit[2], Hubert Ebert[3], and Jan Minár[3] — [1]MPI-CPFS Dresden — [2]STFC Daresbury Laboratory, UK — [3]LMU München

Using the fully-relativistic Green's function formalism we analyze the electronic structure topology in series of the heavy rock-salt type semiconductors PuX, SmX (X=Te, Se, S). Due to the partial filling of their f-shells, these materials exhibit strong dynamical correlations which destroy the Bloch-like eigenstates. Thus, the usual analysis based on the symmetry of the eigenstates cannot be applied. Here we recall the adiabatic approach, which allows to analyze the topology based on a purely bulk information disregarding the Bloch or localized character of the electronic states. The dynamical correlations were treated within the DMFT scheme implemented in the framework of the SPR-KKR Green's function method.

MA 5.10 Mon 17:45 H10

Correlation between linear Magnetoresistance and Mobility of Heusler Topological Insulators — •C. Shekhar, A. K. Nayak, S. Ouardi, G. H. Fecher, and C. Felser — Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany

Topological insulators (TIs) are a class of quantum materials and belong to a new state of matter with topologically protected gapless Dirac fermionic states. Among the TIs series Heusler compounds are promising candidates for the nanoelectronic devices. If these compounds contain heavy metals (Au, Pb, Pd, Pt, Sb and Bi) and a lanthanide element then they exhibit extraordinary physical properties including *zero band gap*. Generally, gapless compounds show high mobility, where no threshold energy is required to conduct carriers from occupied states to empty states. Very recently, the exciting discovery of graphene is an example of high-mobility compounds due to its linear dispersion of the bands, where charge carriers behave like massless particles. However, the Heusler TIs having *zero band gap* are also expected to show high mobility. The Heusler TIs also exhibit nonsaturating and positive magnetoresistance, that shows systematic variations with temperature. The best fitting of observed MR is found with the combination of linear and quadratic field dependence and may be written in form of a quadratic equation: $\mathrm{MR} = a|B| + (b/2)B^2$, where B is applied field. It is clear that this MR originates from the contribution of both linear and parabolic terms. The parabolic term is well known and comes from the Lorentz force, while the origin of the linear MR is intriguing.

MA 6: Focused Session: Correlations in Topological Bands (jointly with DS, HL, MA, and O)

Topological ideas have been among the most profound recent additions to the field of condensed matter physics, and they have provided some of the most unexpected new developments, most recently through the proposed existence of fractional Chern insulators: these are lattice systems in which fractional quantum Hall physics occurs in partially filled non-dispersive topological "Chern" bands. Our ability to create such environments is central to advancing the understanding of correlated electron physics.

This session focuses on the twin aspects of the new physics that can be found in such settings on one hand, and recent progress towards realizing such settings on the other. It contains theoretical and experimental contributions, from nano-, semiconductor and cold atomic physics.

Organizer: Roderich Moessner (MPI PKS, Dresden)

Time: Monday 15:00–17:45 Location: H20

Invited Talk MA 6.1 Mon 15:00 H20

Designer Dirac Fermions, Topological Phases, and Gauge Fields in Molecular Graphene — •Hari C. Manoharan — Dept. of Physics, Stanford University, Stanford, California 94305, USA

Using low-temperature scanning tunneling microscopy and spectroscopy, we show the emergence of Dirac fermions in a fully tunable condensed-matter system—molecular graphene—assembled via atomic manipulation of a conventional two-dimensional electron system in a surface state. We embed, image, and tune the symmetries underlying the two-dimensional Dirac equation into these electrons by sculpting the surface potential with manipulated molecules. By distorting the effective electron hopping parameters into a Kekulé pattern, we find that these natively massless Dirac particles can be endowed with a tunable mass engendered by the associated scalar gauge field, in analogy to the Higgs field. With altered symmetry and texturing of the assembled lattices, the Dirac fermions can be dressed with gauge elec-

tric or magnetic fields such that the carriers believe they are in real fields and condense into the corresponding ground state, as confirmed by tunneling spectroscopy. Using these techniques we ultimately fabricate a quantum Hall state without breaking time-reversal symmetry, in which electrons quantize in a gauge magnetic field ramped to 60 Tesla with zero applied laboratory field. We show that these and other chiral states now possible to realize have direct analogues in topological insulators, and can be used to guide or confine charge in nontrivial ways [1].

[1] Gomes et al., Nature **483**, 306–310 (2012).

Invited Talk MA 6.2 Mon 15:30 H20

Fractional Topological Insulators — •Claudio Chamon[1], Christopher Mudry[2], Titus Neupert[2], and Luiz Santos[3] — [1]Boston University — [2]Paul Scherrer Institute — [3]Perimeter Institute

The prediction and experimental discovery of topological band insulators and topological superconductors are recent examples of how topology can characterize phases of matter. In these examples, electronic interactions do not play a fundamental role. In this talk we shall discuss cases where interactions lead to new phases of matter of topological character. Specifically, we shall discuss fractional topological states in lattice models which occur when interacting electrons propagate on flattened Bloch bands with non-zero Chern number. Topologically ordered many-particle states can emerge when these bands are partially filled, including a possible realization of the fractional quantum Hall effect without external magnetic fields. We also discuss the importance of geometric band attributes to stabilize certain fractional states, highlighting the importance of geometry and not just topology for reaching fractional states of matter.

Topical Talk MA 6.3 Mon 16:00 H20

Hierarchy of Fractional Chern Insulators and Competing Compressible States — •Andreas Läuchli — Institut für Theoretische Physik, Universität Innsbruck, A-6020 Innsbruck, Österreich

The recent engineering of simple tight binding models harboring flat bands with non-zero Chern number calls for a detailed study of the possible many-body phases occurring in partially filled Chern bands and their analogies and differences compared to the continuum Landau level problem. We first report the numerical phase diagram for a flat Chern band with $C = 1$ on the checkerboard lattice, where we find hierarchy multiplets of incompressible states at various fillings ν These are accounted for by an analogy to Haldane pseudopotentials extracted from an analysis of the two-particle problem. Important distinctions to standard fractional quantum Hall physics are striking: absent particle-hole symmetry in a single band, an interaction-induced single-hole dispersion appears, which perturbs and eventually destabilizes incompressible states as ν increases [1]. In second study we investigate the occurrence of fractional Chern insulating phases in a series of bands with higher Chern numbers $C = N > 1$. We find compelling evidence for a series of stable states at $\nu = 1/(2N + 1)$ for fermions as well as bosonic states at $\nu = 1/(N + 1)$. By examining the topological ground state degeneracies and the excitation structure as well as the entanglement spectrum, we conclude that these states are Abelian [2].

[1] A. M. Läuchli, Z. Liu, E.J . Bergholtz, and R. Moessner, arxiv:1207.6094 (2012)
[2] Z. Liu, E. J. Bergholtz, H. Fan, and A. M. Läuchli, Phys. Rev. Lett. **109**, 186805 (2012)

15 min. break

Topical Talk MA 6.4 Mon 16:45 H20

Designing Topological Bands for Ultracold Atomic Gases — •Nigel Cooper — Cavendish Laboratory, University of Cambridge, UK

One of the most important techniques in the ultracold atom toolbox is the optical lattice: a periodic scalar potential formed from standing waves of light. Optical lattices are central to the use of atomic gases as quantum simulators, and allow the exploration of strong-correlation phenomena related to condensed matter systems. I shall describe how to design new forms of optical lattice - so-called "optical flux lattices" - in which optically dressed atoms experience a periodic effective magnetic flux with high mean density. Optical flux lattices have narrow energy bands with nonzero Chern numbers, analogous to the Landau levels of a charged particle in a uniform magnetic field. These lattices will greatly facilitate the achievement of the quantum Hall regime for ultracold atomic gases.

Topical Talk MA 6.5 Mon 17:15 H20

Probing Topological Bloch Bands Using Ultracold Quantum Gases — •Immanuel Bloch — Max-Planck Institut für Quantenoptik, Garching, Germany — Ludwig-Maximilians Universität, München, Germany

Over the past years, ultracold quantum gases have emerged as highly controllable testbeds for probing fundamental condensed matter phenomena. In my talk, I will show how strong effective magnetic fields can be realized for neutral atoms held in an especially engineered optical lattice potential. The effective field strengths that can be reached, are 10-100 times larger than what can be achieved even with the strongest magnets in real material systems, allowing one to take the artificial quantum matter into a new parameter regime. Furthermore, I will show how by carrying out matter wave interferometry within the Bloch bands, we have been able to measure the Zak phase - the Berry phase in one dimension - and to directly determine topological invariants. As an example, I will present results for the celebrated Su-Schrieffer-Heeger model of polyacetylene that can be modelled by using optical superlattice potentials.

MA 7: Magnetic Particles in Biomedical Diagnostics and Therapy (jointly with BP,CPP,ST)

Time: Monday 9:30–11:15 Location: H22

Invited Talk MA 7.1 Mon 9:30 H22

Time-of-Flight Magnetic Flow Cytometry — •Michael Helou[1,4], Mathias Reisbeck[1], Lukas Richter[1], Jacobus Bosch[2], Roland Stauber[3], Eckhard Quandt[4], and Oliver Hayden[1] — [1]Siemens AG, Corporate Technology, 91058 Erlangen, Germany — [2]Department of Medicine 5, Hematology and Medical Oncology, University Hospital Erlangen, 91054 Erlangen, Germany — [3]Molecular and Cellular Oncology/Mainz Screening Center (MSC), Medical University Mainz, 55101 Mainz, Germany — [4]Institute for Materials Science-Inorganic Functional Materials, Christian-Albrechts-Universität zu Kiel, 24143 Kiel, Germany

Flow cytometry - the gold standard for clinical single cell analysis - requires a point-of-care solution for decentralized applications. Here, we show a novel approach towards a time-of-flight magnetic flow cytometry using superparamagnetic iron-oxide nanoparticles (SPION) labeled cells. Within a microfluidic channel we are able to perform specific cell enrichment and cell focusing by magnetophoresis as well as single cell detection with integrated GMR sensors in a single step. We even take advantage of the magnetophoresis for an in-situ elimination of the background from non-bound markers. In addition, time-of-flight measurements of the labeled cells allow us to derive cell diameter information. Proof-of-concept of our magnetic flow cytometer is demonstrated with SPION labeled tumor cells spiked in stabilized whole blood.

15 min. break

MA 7.2 Mon 10:15 H22

Effect of ferritin on spin of NV centre in diamond — •Anna Ermakova[1], Goutam Pramanik[2], Jianming Cai[3], Boris Naydenov[1], Liam McGuinness[1], Fedor Jelezko[1], Tanja Weil[2], and Martin Plenio[3] — [1]Institute of Quantum Optics, University Ulm — [2]Institute of Organic Chemistry III, University Ulm — [3]Institute of Theoretical Physics, University Ulm

The nitrogen-vacancy (NV) centre is a stable optical centre in diamond, which also has application in sensing. Spin of NV centre has high sensitivity of the magnetic field and can be use like a magnetic detector with nanoscale resolution [1,2]. Moreover, diamond is a biocompatible material and nanodiamonds (NDs) are known to be non-toxic for a variety of cells [3]. It*s mean that spin properties of nitrogen-vacancy centre in ND can find wide application in medicine diagnostic. In this

work we used NDs with 30 nm in size, which were attached with ferritin. Ferritin is hollow protein shells that can store 2500-4000 iron atoms and is 8 nm in diameter. It is a important component of a human blood. Ferritin saves human from toxic free iron atoms and keeps iron to produce haemoglobin in further. One ND has around 10 ferritin molecules. Here, we present the change of relaxation times of spin of NV centre in NDs with attached ferritin. We observed that T1 and T2 of NDs with ferritin molecules are less by five times than of free NDs. We also show the theoretical model which explains these changes. 1) Balasubramanian G. et al. Nature 455 (2008),648-651 2) J.M.Taylor, P.Capellaro et al., Nature Physics,4,810*816 (2008) 3) A.M.Schrand et al., J Phys Chem B, vol.111,No.1(2007),2-7

MA 7.3 Mon 10:30 H22

Realization of homogeneous bioassays using magnetic nanoparticles in time-varying magnetic fields — •Frank Ludwig, Thilo Wawrzik, Jan Dieckhoff, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Str. 66, D-38106 Braunschweig

Homogeneous bioassays utilizing functionalized magnetic nanoparticles (MNP) are based on the MNP's dynamics in time-varying magnetic fields which differs for bound and unbound markers. For this the dynamics of unbound markers must be dominated by the Brownian mechanism whereas bound ones relax either via the Brownian mechanism with an increased time constant or via the Néel mechanism. In our group, the following principal approaches for the realization of homogeneous bioassays with MNP are pursued: With our fluxgate magnetorelaxometry (MRX) setup, the dynamics is studied in the time domain and time constants between about 400 μs and a few s are accessible. With our ac susceptibility (ACS) systems, the dynamics is studied in the frequency domain for excitation field frequencies between a few tens of Hz and 1 MHz. Similarly to the ACS technique, the MNP can be exposed to a rotating magnetic field, and the phase lag between field and sample moment is studied. In magnetic particle spectroscopy (MPS), the harmonic spectrum of the MNP sample is measured in a large sinusoidal magnetic field. Examples for the realization of homogeneous binding experiments utilizing the different techniques will be presented. This work was supported by the FP 7 project NMP-2010-246479 and by the DFG via SFB 578.

MA 7.4 Mon 10:45 H22

Direct Protein Detection in the Sample Solution by Monitoring Rotational Dynamics of Nickel Nanorods — •Stefan Schrittwieser[1], Frank Ludwig[2], Jan Dieckhoff[2], Andreas Tschoepe[3], Annegret Guenther[3], Michael Richter[1], Andreas Huetten[4], Hubert Brueckl[1], and Joerg Schotter[1] — [1]AIT Austrian Institute of Technology, Vienna, Austria — [2]TU Braunschweig, Braunschweig, Germany — [3]Universitaet des Saarlandes, Saarbruecken, Germany — [4]Bielefeld University, Bielefeld, Germany

We present experiments that demonstrate the feasibility of a recently introduced homogeneous immunodiagnostic approach to directly detect analyte binding by optical observation of the hydrodynamic properties of magnetically rotated nanorods ("PlasMag"). Specifically, we show that the phase lag of the long axis of nickel nanorods (magnetic core parameters: length 182 nm, diameter 26 nm) with respect to externally applied rotating magnetic fields significantly increases on the adhesion of bovine serum albumin (BSA) protein to their surfaces. To validate these results, we independently determine the amount of bound protein molecules by analysis of the electrophoretic mobility of the nanorods, which gives a protein surface density of 5.8 femtomol / mm^2.

Acknowledgements: The research leading to these results has received funding from the European Community's 7th Framework Programme under grant agreement no 246479 (NAMDIATREAM).

MA 7.5 Mon 11:00 H22

Bioassay based on the response of magnetic nanoparticles to rotating magnetic fields — •Jan Dieckhoff, Meinhard Schilling, and Frank Ludwig — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Str. 66, 38106 Braunschweig

The possibility to directly affect the dynamics of magnetic nanoparticles in a magnetic field via the binding of target molecules to the particles functionalized surfaces has led to the realization of different homogeneous bioassays. Besides the frequently applied alternating magnetic field, the rotating magnetic field offers an interesting alternative for the manipulation of the magnetic nanoparticles. In the rotating magnetic field the nanoparticles experience a rotational motion according to the rotating field frequency and amplitude. Due to drag forces and thermal energy, a phase lag between the rotating field and the nanoparticles magnetization occurs which depends strongly on the particles hydrodynamic size. Analyzing this value, a robust and precise homogeneous bioassay can be realized, that offers a higher sensitivity compared to the alternating magnetic field mode. In this presentation, simulation and measurement results of binding experiments in an alternating and rotating magnetic field are presented and analyzed. Moreover, challenges regarding the magnetic nanoparticles and possible approaches are discussed. This work was supported by the European Commission Framework Programme 7 under the NAMDIATREAM project (NMP-2010-246479).

MA 8: Spin Excitations and Spin Torque

Time: Monday 9:30–12:30 Location: H23

MA 8.1 Mon 9:30 H23

Impact of Atomic Structure on the Magnon Dispersion Relation: Fe(111)/Au/W(110) and Fe(110)/W(110) — •Tzu-Hung Chuang[1], Khalil Zakeri[1], Arthur Ernst[1], Leonid M. Sandratskii[1], Pawel Buczek[1], Yu Zhang[1], Huajun Qin[1], Waheed Adeagbo[2], Wolfram Hergert[2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Seckendorff-Platz 1, D-06120 Halle, Germany

We present a combined experimental and theoretical study of the correlation between the atomic structure and magnon energies in ultrathin Fe films. High wave-vector magnon excitations in a 2 monolayer (ML) Fe(111) film grown in an fcc-like stacking on 2ML Au/W(110) are probed by spin-polarized electron energy loss spectroscopy. The results are compared to the ones of a bcc-like film directly grown on W(110). It is found that the magnon energies in Fe(111)/Au/W(110) are lower than the ones in Fe(110)/W(110). Our calculations confirm the experimental results revealing a strong dependency of exchange interaction on the atomic structure. In the Fe/Au/W structure, it is observed that the intralayer exchange interactions increase with increasing distance between Fe atomic layers. This effect can be understood based on the complexity of the electronic structure and the contribution of different orbitals to the hybridization and exchange interaction [1].

[1] T.-H. Chuang, Kh. Zakeri, A. Ernst, L. M. Sandratskii, P. Buczek, Y. Zhang, H. J. Qin, W. Adeagbo, W. Hergert, and J. Kirschner, Phys. Rev. Lett. **109**, 207201 (2012).

MA 8.2 Mon 9:45 H23

Strong magnon softening in tetragonal FeCo compounds: An *ab initio* many-body perturbation theory study — •Ersoy Sasioglu, Christoph Friedrich, and Stefan Blügel — Peter Grünberg Institut and Institute forAdvanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Magnons play an important role in fast precessional magnetization reversal processes serving as a heat bath for dissipation of the Zeeman energy and thus being responsible for the relaxation of magnetization [1]. Employing *ab initio* many-body perturbation theory [2] within the framework of the full-potential linearized-augmented plane-wave (FLAPW) method [3], we have studied the magnon spectra of the tetragonal FeCo compounds considering three different experimental c/a ratios, c/a =1.13, 1.18, and 1.24 corresponding to FeCo grown on Pd, Ir, and Rh, respectively. We find that for all three cases the short-wave-length magnons are strongly damped and tetragonal distortion gives rise to a significant magnon softening. The magnon stiffness constant D decreases almost by a factor of two from FeCo/Pd to FeCo/Rh. The combination of soft magnons together with the giant magnetic anisotropy energy suggests FeCo/Rh to be a promising material for perpendicular magnetic recording applications.

[1] K. Baberschke, physica status solidi (b) **245**, 174 (2008).
[2] E. Şaşıoğlu, A. Schindlmayr, C. Friedrich, F. Freimuth, and S. Blügel, Phys. Rev. B **81**, 054434 (2010).
[3] http://www.flapw.de

MA 8.3 Mon 10:00 H23

Imaging of spin transfer torque induced magnetization reversal — •Matthias Buhl[1], Jochen Grebing[1], Sebastian Wintz[1], Jörg Raabe[2], Jürgen Fassbender[1], and Artur Erbe[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Paul Scherrer Institut, Villigen, Switzerland

Setting the magnetic state of nanostructures can be used for durable information storage. For future applications, this process needs to be developed towards true nanoscale dimensions in order to keep up the miniaturization speed of modern nanoelectronic components. Therefore, new concepts for controlling the state of nanomagnets are currently in the focus of research in the field of nanoelectronics. Here, we demonstrate the magnetic characterization of purely metallic nanopillars placed on a lead that conducts a spin-polarized current at room temperature. The structures are fabricated by means of electron beam lithography. Spin diffusion across the metal-metal (Cu to CoFe) interface between the pillar and the lead causes spin accumulation in the pillar, which may then be used to set the magnetic orientation of the pillar. Reproducible switching of the magnetization of the pillar is observed by direct imaging via scanning transmission x-ray microscopy (STXM).

MA 8.4 Mon 10:15 H23

Spin Torque Ferromagnetic Resonance in MgO-based Magnetic Tunnel Junctions — •Yuriy Aleksandrov[1,2], Alina M. Deac[1], Kerstin Bernert[1,2], Ciaran Fowley[1], Volker Sluka[1], Ewa Kowalska[1], Jürgen Lindner[1], and Jürgen Fassbender[1,2] — [1]HZDR, Dresden, Germany — [2]TU Dresden, Dresden, Germany

Spin polarized currents can exert a torque on a ferromagnetic layer's magnetic moment leading to switching or steady-state precession. Spin-torque driven ferromagnetic resonance (ST-FMR) is a unique method to measure the magnetic anisotropy, saturation magnetization and damping in a nanoscale structure. ST-FMR can also be used to determine the bias dependence of spin-transfer torques in magnetic tunnel junctions [1- 3]. For different values of applied RF power and DC bias, we swept the RF frequency from 1 to 15 GHz and measured the resulting mixing voltage across our MgO-based tunnel junctions. Not only the low-frequency fundamental mode was observed, but also a higher order mode. We find that the mixing voltage peak shifts with applied DC-field and increases with RF power. Finally, we separate the field-like torque contribution from that of the in-plane spin-transfer torque and determine their bias dependence.

[1] A. Deac et al., Nature Phys. 4, 803 (2008).
[2] H. Kubota et al., Nature Phys. 4, 37 (2008).
[3] J. C. Sankey et al., Nature Phys. 4, 67 (2008).

MA 8.5 Mon 10:30 H23

Minimizing the Fano factor of spin shot noise in a nano-oscillator — •Jacek Swiebodzinski — Theoretische Physik, Universität Duisburg-Essen and CENIDE, 47048 Duisburg, Germany

A spin polarized current may transfer angular momentum to a free ferromagnet resulting in the celebrated spin-torque phenomenon. If its amplitude and direction are fine-tuned in such a way that the magnetic damping is compensated for, the microscopic torque may lead to an undamped steady-state precession of the magnetization vector in sufficiently small samples. The linewidth of such a nano-oscillator is a result of thermal and non-thermal sources of noise. A prominent source of non-equilibrium noise in spin-torque systems is the spin shot noise [1]. It is a consequence of the discreteness of the angular momentum transfer and as such present in every spin-torque experiment. Here, we introduce the Fano factor of the spin shot noise. For a spin-torque nano-oscillator we calculate the voltage dependence of the Fano factor and show that there is an optimal precession angle at which the Fano factor is minimized [2]. In particular at low temperatures, where the spin shot noise constitutes a dominant contribution to magnetization noise, our findings are of practical importance for an efficient operation of nano-oscillators.

[1] A. L. Chudnovskiy, J. Swiebodzinski, and A. Kamenev, Phys. Rev. Lett. **102**, 066601 (2008).
[2] J. Swiebodzinski, Phys. Scr. **T151**, 014024 (2012).

MA 8.6 Mon 10:45 H23

Thermally Excited Ferromagnetic Resonance in MgO-based Magnetic Tunnel Junctions — •Ewa Kowalska[1], Yuriy Aleksandrov[1,2], Kerstin Bernert[1,2], Ciaran Fowley[1], Volker Sluka[1], Jürgen Lindner[1], Jürgen Fassbender[1,2], and Alina Deac[1] — [1]HZDR, Dresden, Germany — [2]TU Dresden, Germany

Spin polarized currents can exert a so-called spin-transfer torque to the magnetic moment of a ferromagnetic layer. One application of this phenomenon is the spin torque nano-oscillator (typically an MgO-based magnetic tunnel junction (MTJ)) which can act as a tunable microwave emission source. However, a more detailed understanding of the spin-torque physics is needed. For example, the spin torque bias dependence of the two spin torque components (in-plane and field-like) is still widely discussed in the community [1]. We present results for MgO-MTJs obtained by thermally excited ferromagnetic resonance (TE-FMR). With the help of TE-FMR, the bias dependence of the two spin-transfer torques can be determined from the peak position and linewidth [2]. Microwave measurements were carried out in the frequency range of 1-9 GHz at positive and negative magnetic fields and for different dc current values. Analyzing this data, we could separate the in-plane and field-like spin torque components and determine their bias dependence.

[1] M. H. Jung et al., PRB 81, 134419 (2010).
[2] A. Deac et al., Nature Phys. 4, 803 (2008).

15 min. break

MA 8.7 Mon 11:15 H23

Concentration dependence of the tunnel magnetoresistance and spin-transfer torque in FeCo/MgO/FeCo tunnel junctions — •Christian Franz, Michael Czerner, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, Giessen, Germany

We investigate magnetic tunnel junctions with $Fe_{1-x}Co_x$ alloys as magnetic layers and a MgO barrier. We calculate *ab initio* the tunnel magnetoresistance (TMR) and spin-transfer torque (STT) for zero and finite bias voltage and analyze their dependence on the concentrations. We describe the transport processes using a non-equilibrium Green's function method, which was implemented in a KKR method. The FeCo alloys are described by the coherent potential approximation (CPA). In the CPA calculations we incorporate non-equilibrium vertex corrections. The alloy scattering, which is included in the CPA description, leads to a broadening of the bands. As a result, we find that in the voltage dependence of TMR and STT resonant features are smeared out for finite concentrations. For zero bias the TMR shows only a weak concentration dependence for intermediate concentrations but a strong enhancement towards the pure components. At a finite bias of 0.54 V we find that the TMR strongly decreases with the Co concentration. The investigation of the concentration dependence of the STT shows that, while the interlayer exchange coupling decreases with the Co concentration, the linear bias dependence of the in-plane-torque is independent of the concentration. Thus our results favour high Fe concentrations in order to obtain a high TMR and STT.

MA 8.8 Mon 11:30 H23

Perpendicular anisotropy in CoFeB/MgO - based magnetic tunnel junctions — •Vladyslav Zbarsky[1], Marvin Walter[1], Maria Mansurova[1], Christian Leutenantsmeyer[1], Tim Eggebrecht[1], Karsten Rott[2], Günter Reiss[2], Rashid Gareev[3], Tae Hee Kim[4], and Markus Münzenberg[1] — [1]I. Physikalisches Institut, Universität Göttingen, — [2]Physikalisches Institut, Universität Bielefeld — [3]Physikalisches Institut, Universität Regensburg — [4]Department of Physics, Ewha Womans University Korea

The reduction of the switching current density is important for spin-transfer torque based MRAM and predicted for the magnetic tunnel junctions (MTJs) with perpendicular magnetic anisotropy (PMA). The first experiments show that the thicknesses of CoFeB and MgO layers are crucial for the out-of-plane magnetic behaviour. In this context, samples with a CoFeB thickness gradient were fabricated and MOKE measurements as well as electrical characterization carried out. For CoFeB layers below 1.3 nm a perpendicular anisotropy is observed. On those samples, MTJs with 155 nm diameter show STT with a very low switching current density of $2 \cdot 10^5$ A/cm^2. Samples with higher CoFeB thickness show a change of magnetic behaviour from out-of-plane to in-plane easy axis. To investigate the influence of the MgO

interface, a thin Co layer is inserted at one of the MgO interfaces and its influence on the magnetic anisotropy is studied.

MA 8.9 Mon 11:45 H23

Fabrication of CoFeB|MgO|CoFeB magnetic tunneljunctions with ultrathin barriers for thermal spin transfer torque — •Johannes Christian Leutenantsmeyer[1], Marvin Walter[1], Vladyslav Zbarsky[1], Patrick Peretzki[2], Henning Schuhmann[2], Michael Seibt[2], Karsten Rott[3], Günter Reiss[3], Andy Thomas[3], and Markus Münzenberg[1] — [1]I. Phys. Inst., Universität Göttingen — [2]IV. Phys. Inst., Universität Göttingen — [3]Thin Films and Physics of Nanostructures, Universität Bielefeld

Thermal spin-transfer torque (T-STT) describes the combination of the spin-transfer torque effect with the spin-caloric magneto-Seebeck effect. Here, thermally excited electrons are used to manipulate the magnetization of a magnetic tunneljunction (MTJ). Calculations have been performed in 2011 [1] suggesting a switching T-STT at temperature gradients in the order of 10 K in MTJs with 3 monolayer (ML) MgO barriers. The effect is suitable for storage application, enhancing the energy efficiency of those devices.

We have fabricated CoFeB/MgO MTJs with 3 ML MgO barriers and reasonable interface roughness. For different deposition parameters (in particular MgO growth temperature), the quality of the interface was studied via quantitave HR-TEM analysis. Characterization shows a TMR-effect of up to 55% in nanoscaled junctions. Also spin-transfer torque was observed in 4 ML junctions. MTJs with 4 ML MgO and perpendicular magnetization anisotropy (PMA) show ultra low switching currents (0.2 MA/cm^2), making PMA MTJs suitable for T-STT.

[1] Jia et al., PRL **107** 176603, 2011

MA 8.10 Mon 12:00 H23

Current induced domain wall nucleation and motion in an out-of-plane magnetized CoFeB-MgO nanowire — •Tomek Schulz[1], Tim Zacke[1], Su-Jung Noh[1], Berthold Ocker[2], Capuciné Burrowes[3], Dafiné Ravelsona[3], and Mathias Kläui[1] — [1]Instute of Physics, Johannes Gutenberg-Universität Mainz, Germany — [2]Singulus Technologies AG, Kahl am Main, Germany — [3]Institut d'Electronique Fondamentale, Universite Paris-sud, France

For read-out of a racetrack device, an appropriate material compositions that is compatible with high TMR MgO barriers has been developed. We report on transport measurements on a magnetic nanowire structure consisting of a Ta/CoFeB/MgO/Ta-multilayer with a perpendicular magnetization anisotropy. By applying single short current pulses through a gold wire on top of the nanowire it is possible to nucleate domain walls only by the generated Oersted field. After the nucleation, we investigated the properties of this multilayer stack for current induced domain wall motion and found very low propagation fields.

MA 8.11 Mon 12:15 H23

Current induced Domain Wall Motion in Rashba nanowires — •Martin Stier[1], Reinhold Egger[2], and Michael Thorwart[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg — [2]Institut für theoretische Physik, Heinrich-Heine-Universität, D-40225 Düsseldorf

We consider the current-induced motion of a Bloch domain wall in an thin ferromagnetic nanowire with strong Rashba spin-orbit coupling. By including intrinsic and extrinsic relaxation mechanisms, we calculate the full nonadiabatic spin torque. In particular, we show that a nonadiabatic local magnetic Rashba field $\mathbf{H}_R$ arises which can become large for small dampings β. Our theory predicts that with increasing spin-orbit coupling strength, domain wall motion progresses from purely translatory to oscillatory dynamics. For pulsed currents, depending on the pulse length, rich behavior is found, including wall motion *against* the current direction and a strong enhancement of the wall velocity.

MA 9: Spincaloric Transport (jointly with TT)

Results -partially also obtained in DFG Priority Program "Spin Caloric Transport" SPP1538 (www.spincat.info)- on spin-dependent transport phenomena initiated and controlled by thermal effects in magnetic nanostructures are discussed.

Time: Monday 15:00–18:45 Location: H22

MA 9.1 Mon 15:00 H22

Transverse magneto-thermoelectric effects in Permalloy films. — •Sasmita Srichandan, Maximilian Schmid, Michael Vogel, Christoph Strunk, and Christian Back — Institute of experimental and applied Physics, University of Regensburg, 93040 Regensburg, Germany

Thermally induced transversal magneto transport phenomena have been studied on 20 nm Py films deposited on MgO and GaAs substrates as well as on 100 nm thick SiN membranes. With an in plane thermal gradient ∇T, the transverse voltage V_T is measured on 10nm thick patterned Pt stripes on top of the Py films with respect to applied external magnetic field B at an angle θ where θ is the the angle between B and ∇T. The observed $\sin\theta\cos\theta$ dependence of V_T indicates the planar Nernst effect (PNE). Additionally we observe an asymmetry in the signal between the positive and negative B directions which is proportional to $\cos\theta$. This can be attributed to the anomalous Nernst effect (ANE) caused by a temperature gradient normal to the plane of the sample resulting from thermal radiation. The contribution of the transverse spin Seebeck effect (TSSE) which shares the same $\cos\theta$ symmetry as the ANE, has been separated and it turns out to be one order smaller than reported in the literature [1]. The above measurements have also been performed on SiN membranes and they result in Nernst signals being an order higher than for bulk samples owing to the large local T gradient.

[1] K. Uchida et.al, Observation of spin Seebeck effect. Nature **455**,778-781(2008).

MA 9.2 Mon 15:15 H22

Tunnel magneto-Seebeck effect in high temperature gradients — •Marvin Walter[1], J. C. Leutenantsmeyer[1], V. Zbarsky[1], T. Eggebrecht[1], M. Münzenberg[1], K. Rott[2], A. Böhnke[2], G. Reiss[2], A. Thomas[2], M. Czerner[3], and C. Heiliger[3] — [1]I. Phys. Inst., Universität Göttingen, Germany — [2]Dept. of Physics, Bielefeld University, Germany — [3]I. Phys. Inst., Universität Giessen, Germany

CoFeB/MgO/CoFeB devices showing a giant TMR effect are possible candidates for the generation of spin-currents by thermal heating and the tunnel magneto-Seebeck effect was already observed. It is theoretically predicted that for a 3 monolayer MgO barrier the torque of the spin-polarized tunneling electrons might be sufficient to observe thermal spin transfer torque (T-STT).

The samples presented in this work consist of a minimal pseudo-spin-valve stack with sputtered Ta and CoFeB layers and an e-beam evaporated MgO barrier with thicknesses down to 3 monolayers. The MTJs are heated by a Ti:Sa femtosecond laser to achieve high temperature gradients. The heating of the MTJ by a femtosecond laser is simulated using finite element methods. Using the parameters observed in the experimental setup, the simulations show temperature differences across the MgO barrier of more than 10K for a duration in the order of picoseconds. This temperature difference should be sufficient to achieve T-STT. Furthermore, the thermomagnetoelectric properties in high temperature gradients of MTJs with perpendicular magnetic anisotropy and switching current densities of $2 \cdot 10^5$ A/cm^2 are investigated.

MA 9.3 Mon 15:30 H22

Spin-filtering efficiency of ferrimagnetic spinels $CoFe_2O_4$ and $NiFe_2O_4$ — Nuala Caffrey[1], Daniel Fritsch[2], Tom Archer[1], Stefano Sanvito[1], and •Claude Ederer[3] — [1]School of Physics and CRANN, Trinity College Dublin, Ireland — [2]H. H. Wells Physics Laboratory, University of Bristol, United Kingdom — [3]Materials Theory, ETH Zurich, Switzerland

We assess the potential of the ferrimagnetic spinel ferrites $CoFe_2O_4$ and $NiFe_2O_4$ to act as spin-filtering barriers in magnetic tunnel junctions. Our study is based on the electronic structure calculated by

means of first-principles approaches within different approximations for the exchange correlation energy. We show that, in agreement with previous calculations, the densities of states suggest a lower tunneling barrier for minority spin electrons, and thus a negative spin-filter effect. However, a more detailed analysis based on the complex bandstructure reveals that both signs for the spin-filtering efficiency are possible, depending on the band alignment between the electrode and the barrier material.

MA 9.4 Mon 15:45 H22

Longitudinal spin Seebeck effect and anomalous Nernst effect in thin $NiFe_2O_4$/Pt films — •Daniel Meier[1], Timo Kuschel[1], Liming Shen[2], Arunava Gupta[2], Takashi Kikkawa[3], Ken-ichi Uchida[3], Eiji Saitoh[3], Jan-Michael Schmalhorst[1], and Günter Reiss[1] — [1]University of Bielefeld, Germany — [2]University of Alabama, Tuscaloosa, USA — [3]Tohoku University of Sendai, Japan

When a temperature gradient is applied along a ferromagnet/Pt system a spin current parallel to this temperature gradient is generated, which can be converted into an electromotive force (V_{Pt}) via the inverse spin Hall effect in the Pt. One can measure a voltage between the ends of the Pt film in a range of a few μV. In a ferromagnetic insulator/Pt system no regions are expected which are conductive and spin-polarized simultaneously. That is the reason why thermomagnetic effects like the anomalous Nernst effect could be neglected.
In this work we present data for the conductivity of the $NiFe_2O_4$ films and for V_{Pt} taken for $NiFe_2O_4$ films with a thin Pt film on top obtained in a setup for measurements at room temperature and in another one for investigations in a low temperature range. The $NiFe_2O_4$ films show semiconductive characteristics. Therefore, a detailed temperature dependence is studied as well as the influence of direction of an external magnetic field. The origin of the measured effects is discussed on the base of temperature dependent conductivity measurements in order to correlate the longitudinal spin Seebeck effect and the anomalous Nernst effect.

MA 9.5 Mon 16:00 H22

Dynamics of domains in thermal gradients — •Frank Schlickeiser, Denise Hinzke, and Ulrich Nowak — Universität Konstanz, 78457 Konstanz, Germany

Many of the recently proposed future magnetic storage devices are based on laser-pulse or current-induced writing schemes, as for example opto-magnetic writing [1]. An unavoidable by-product of these writing schemes are thermal gradients, so that the understanding of their interaction with magnetic structure becomes important. We investigate the dynamics of domains in thin ferromagnetic CoPd films triggered by thermal gradients by means of computer simulations, based on the Landau-Lifshitz-Bloch-equation. The latter describes the dynamics of a thermally averaged spin polarization on micro-magnetic length scales [2]. We show that in a Gaussian temperature profile the magnetic structure is modified towards a radial orientation of the domains. Our numerical results are compared with recently performed measurements. We acknowledge financial support by the DFG through SFB 767. [1] K. Vahaplar et al.,Phys. Rev. Lett. 103, 117201 (2009), [2] D. Hinzke and U. Nowak, Phys. Rev. Lett. 107, 027205 (2011).

MA 9.6 Mon 16:15 H22

Thermally excited magnonic spin currents probed by the longitudinal spin-Seebeck effect in YIG — •Andreas Kehlberger[1], René Röser[1], Gerhard Jakob[1], Benjamin Jungfleisch[2], Burkard Hillebrands[2], Ulrike Ritzmann[3], Denise Hinzke[3], Dong Hun Kim[4], Caroline Ross[4], Ulrich Nowak[2], and Mathias Kläui[1] — [1]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [2]Department of Physics, Institute of Technology Kaiserslautern, 67663 Kaiserslautern, Germany — [3]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [4]Department of Materials Science and Engineering, MIT , Cambridge, MA 02139, USA

In the research field of spin caloric transport one of most the prominent and still not understood effects is the spin-Seebeck effect (SSE) in magnetic insulators [1]. Many explanations consider thermally excited magnons as the underling mechanism, for which direct evidence is missing so far. We present a systematic study of the SSE in Yttrium Iron Garnet (YIG) films of different thicknesses. From the thickness dependence of the measured inverse spin Hall effect we can unambiguously identify the SSE effect . Corresponding simulations on atomistic length scales allow us to deduce the propagation length of the thermally excited magnons, which could be used to manipulate domain walls [2]. [1] K. Uchida et al., Nature Mater. 9, 894 (2010) [2] D. Hinzke et al., Phys. Rev. Lett. 107, 027205 (2011)

MA 9.7 Mon 16:30 H22

Laser induced magneto-Seebeck effect on different substrate materials — •Alexander Böhnke[1], Marvin Walter[2], Karsten Rott[1], Andy Thomas[1], Markus Münzenberg[2], and Günter Reiss[1] — [1]Thin Films and Physics of Nanostructures, Bielefeld University, Germany — [2]I. Physikalische Institut, Georg-August-Universität Göttingen, Germany

Since the discovery of the magneto-Seebeck effect [1,2,3] (TMS, *tunnel magneto-Seebeck*) a proper interpretation of the time-resolved voltage traces has been missing [1]. Improvements in the time resolution of the TMS setup now give access to the investigation of the origin of the Seebeck voltage.

Further, we investigated magnetic tunnel junctions (MTJs) on two different substrate materials: Insulating MgO and semiconducting p-doped Si covered by 50 nm of SiO_2. TMS measurements on both sample types lead to same results. However, the time-resolved voltage traces in the case of silicon substrate showed a sharp peak when the laser is turned on. On MgO substrate this peak is not found. SPICE simulations of comparable MTJs on both substrates were performed and can give a first glance on thermal voltages occurring in the layer stacks and the substrates due to laser heating and capacitive coupling.

[1] M. Walter et al., Nat. Mater. 10 (2011), 742.
[2] C. Heiliger et al., Phys. Rev. B 83 (2011), 1.
[3] N. Liebing et al., Phys. Rev. Lett. 107 (2011), 177201.

15 min. break

MA 9.8 Mon 17:00 H22

Ab initio investigations on the magnetothermopower of thin Co/Cu multiple spin-valves — •Voicu Popescu and Peter Kratzer — Faculty of Physics, University Duisburg-Essen, Duisburg, Germany

We have modelled multiple spin-valve configurations by stacking Co and Cu layers of various thickness and number of repetitions. Theoretical investigations on their magneto-thermoelectric properties were performed by calculating the conventional and magnetic Seebeck coefficient using a spin-polarized relativistic implementation of the Landauer-Büttiker conductance formula within the framework of Korringa-Kohn-Rostoker method.

In line with experimental expectations, we find that the anti-parallel (AP) alignment of the adjacent Co layers is characterized by a much larger Seebeck coefficient than the parallel (P) configuration: from $1-2$ μV/K in the P-case, the AP Seebeck coefficient can reach as much as 10 μV/K at room temperature. A correspondence between these values and the giant magneto-resistance characteristic to the Co/Cu spin valves could thus be established.

We show that an increase in the thickness of the Co layer further enhances the magnetothermopower whereas the Cu layer thickness variation has a negligible effect. In addition, we investigate the magnetic anisotropy in the Seebeck coefficient for these systems, by changing the magnetization orientation from parallel to perpendicular to the current. Our results suggest that a strong Seebeck magnetic anisotropy could be detected in typical GMR elements.

MA 9.9 Mon 17:15 H22

Altering the thermopower by magnetic fields — •Steven Achilles[1], Volodymyr V. Maslyuk[2], and Ingrid Mertig[1] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, D-06120 Halle, Germany — [2]Institute of Electron Physics, National Academy of Sciences of Ukraine, 88017 Uzhgorod, Ukraine

Transport properties of nanocontacts are unusual and determined by quantum effects as soon as the characteristic diameter decreases towards the nanometer scale. Besides the investigation of transport properties under low temperature conditions, temperature induced transport becomes more and more important [1].

In this work, we present an ab-initio study of both conductance and thermopower in a non-collinear magnetic system. We focus on an organometallic vanadium-benzene (V_4Bz_5) molecule attached to two Co electrodes oriented in fcc (001) direction with non-collinear magnetic order. Such vanadium-benzene complexes were synthesized and remain stable up to room temperature [2].

We show that, besides the formation of a non-collinear magnetization through the molecule, the sign and magnitude of the thermopower

can be addressed directly altering the orientation of the leads magnetization. Furthermore, a non-monotonous behavior of the thermopower as a function of angle between the lead magnetization directions is found [3].

[1] Reddy et al., Science **315 (5818)**, 1568 (2007).
[2] K. Miyajima et al., Eur. Phys. J. D **34**, 177-182 (2005).
[3] V. V. Maslyuk et al., submitted.

MA 9.10 Mon 17:30 H22

Thermal spin-transfer torques in magnetic tunnel junctions — Michael Czerner, Christian Franz, and •Christian Heiliger — I.Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

The emerging research field of spin caloritronics combines the spin-dependent charge transport with energy or heat transport. In comparison to thermoelectrics the spin degree of freedom is considered as well. We present ab initio calculations based on density functional theory using a Green's function KKR method. We compute the non-equilibrium density in a non-collinear regime, which allows us to calculate the spin-transfer torque. In our investigation we focus on the material dependence of the thermal spin-transfer torque in MgO based tunnel junctions. In particular, we investigate Fe, Co, and FeCo alloys as lead materials. The FeCo alloy is described by the coherent potential approximation (CPA) including vertex corrections for the non-equilibrium density. The thermal spin-transfer torque is calculated for several barrier thicknesses. It turns out that the size of the thermal spin-transfer torque is orders of magnitude smaller than spin-transfer torque at an applied bias voltage. Consequently, the thermal spin-transfer torque can be utilized only for very thin barrier thicknesses.

MA 9.11 Mon 17:45 H22

Quantum Isobaric Process and Thermodynamic Diesel Cycle in Ni_2 — •Chuanding Dong, Georgios Lefkidis, and Wolfgang Hübner — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Box 3049, 67653 Kaiserslautern, Germany

Building thermodynamic cycles with magnetic molecules extends quantum thermodynamics to real systems [1,2] and provides a unique opportunity to explore the thermodynamic properties of the spin degree of freedom. Here we propose a quantum isobaric process in the Ni_2 dimer, and build a quantum Diesel engine [3]. The level scheme of Ni_2 is obtained using *ab-initio* calculation and the perturbative inclusion of an external magnetic field. Our isobaric process is realized by adjusting the bath temperature in dependence on the interatomic distance. The boundary condition of keeping the pressure constant imposes a limitation on the allowed bond lengths, which we call isobaric range.

In the quantum Diesel cycle, since the preceding adiabatic process brings the Ni_2 dimer to a nonequilibrium state, the isobaric process is realized through a modified Boltzmann distribution. Due to its strong effect on the distribution profile, novel features, such as the crossing of the two adiabatic strokes, can appear on the projection on the two-dimensional $P-V$ diagram.

[1] H. T. Quan, Phys. Rev. E **79**, 041129 (2009).
[2] T. D. Kieu, Phys. Rev. Lett. **93**, 140403 (2004).
[3] C. D. Dong, G. Lefkidis, and W. Hübner, J. Supercond. Nov. Magn (in press).

MA 9.12 Mon 18:00 H22

Ab-initio study of the temperature dependent electron transport through magnetic nanostructures — •Roman Kováčik, Phivos Mavropoulos, Daniel Wortmann, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Recent developments in the field of the spin caloritronics have triggered many questions about the origin and character of the observed phenomena (e.g., spin-dependent Seebeck versus spin Seebeck effect [1]). To contribute to the understanding of the underlying mechanisms at the microscopic level, we investigate spin-dependent electron transport through various magnetic nanostructures between non-magnetic leads as a function of the temperature. The electronic structure of the studied systems is calculated within the multiple scattering screened Korringa-Kohn-Rostoker (KKR) Green function framework [2]. The Monte-Carlo methodology is then used to simulate the effect of temperature on the magnetic configurations with the exchange coupling parameters calculated according to [3]. Finally, the Landauer-Büttiker approach for the ballistic transport within the KKR framework [4] is extended to account for the non-collinear magnetic effects. Support from the DFG (SPP 1538) is gratefully acknowledged.

[1] G.E.W. Bauer *et al.*, Nature Mater. 11, 391 (2012).
[2] N. Papanikolaou *et al.*, J. Phys. Condens. Matter 14, 2799 (2002), also see: www.kkr-gf.org.
[3] A.I. Liechtenstein *et al.*, J. Magn. Magn. Mater. 67, 65 (1987).
[4] Ph. Mavropoulos *et al.*, Phys. Rev. B 69, 125104 (2004).

MA 9.13 Mon 18:15 H22

Origin of the spin Seebeck effect in thin films — •Michael Schreier[1], Akashdeep Kamra[2], Mathias Weiler[1], Rudolf Gross[1], and Sebastian T.B. Goennenwein[1] — [1]Walther-Meißner-Institut, Garching, Germany — [2]Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands

The spin Seebeck effect (SSE) originates from a finite temperature difference ΔT between the magnons in a ferromagnet (FM) and the electrons in a normal metal (NM) which supposedly stems from weak magnon-phonon interaction and different boundary conditions on phonon and magnon mediated heat currents. Also, recent experiments [1] suggest that the magnon-phonon interaction is much stronger than originally assumed, which again reduces the expected SSE [2]. Hence the established theory can not account quantitatively for the longitudinal SSE signals in thin films. A factor that has, however, been neglected so far is the Kapitza resistance which leads to an additional contribution to ΔT by introducing a discontinuity in the phonon temperature distribution at the FM/NM interface. This has been modelled using an analytical model and 3D finite elements simulations which show that, for thin layers, the contribution to ΔT originating from the Kapitza resistance is indeed of the same order of magnitude as the one from the original model. Hence the acoustic properties of the FM and NM play an important role in the origin of the SSE. This work is supported by the DFG via SPP1538.

[1] M. Agrawal et al., arXiv (2012)
[2] M. Weiler et al., Phys. Rev. Lett. 108, 106602 (2012)

MA 9.14 Mon 18:30 H22

Scattering-Independent Contribution to the Anomalous Nernst Effect — •Jürgen Weischenberg, Frank Freimuth, Stefan Blügel, and and Yuriy Mokrousov — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

In analogy to the electric conductivity tensor [1], the thermoelectric- or Peltier conductivity tensor may be decomposed into a scattering-dependent and a scattering-independent term. Using the full-potential linearized augmented plane-wave method within the density functional theory, we compute all the contributions to the scattering-independent term, namely the intrinsic contribution and the side-jump contribution, and show that in ferromagnetic materials they are both of equal importance. In particular, the comparison of our theoretical values with experiments suggests that the anomalous Nernst effect in Fe, Co, Ni, FePd and FePt is largely caused by the scattering-independent term [2]. Moreover, the consequences of magnetic disorder on thermoelectric transport phenomena are also discussed. Financial support by the HGF-YIG Programme VH-NG-513 is gratefully acknowledged. J. W. was supported under grant SPP 1538 SpinCaT by the German Science Foundation.

[1] J. Weischenberg, F. Freimuth, J. Sinova, S. Blügel and Y. Mokrousov, PRL **107**, 106601 (2011)
[2] J. Weischenberg, F. Freimuth, S. Blügel and Y. Mokrousov, arXiv:1210.8283 [cond-mat.mtrl-sci]

MA 10: Focus Session: Magnetic Excitations: from surfaces down to adatoms (jointly with O)

Organizer: Stefan Blügel (Forschungszentrum Jülich)

In recent years, major advancements have been made in the study of collective, localized, and discrete excitations in itinerant nanomagnets and atomic quantum magnets. This progress has been triggered by the development of spin-polarized electron energy loss spectroscopy (SPEELS) and by low-temperature scanning probe techniques (STM). These tools probe inelastic spin-dependent phenomena and moved the investigation of inelastic magnetic effects to the forefront of research in nanomagnets. Challenged by these experiments, new theoretical approaches have been developed, e.g. based on time-dependent density functional theory and many-body perturbation theory. In this session, we focus on a variety of new physics in this area of research. We start from the collective excitations in low-dimensional films as measured with SPEELS and inelastic STM and then move to systems of small adclusters and adatoms.

Time: Monday 15:00–17:30 Location: H23

Topical Talk MA 10.1 Mon 15:00 H23

Tailoring magnetic excitations in low-dimensional ferromagnets — •Khalil Zakeri Lori — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

We present a summery of our recent results on elementary magnetic excitations (magnons) in ultrathin ferromagnets. Terahertz magnons in ultrathin Fe(100), Fe(110) and Fe(111) films, grown on different surfaces, are probed by means of spin-polarized high resolution electron energy-loss spectroscopy. The key properties of magnons such as their dispersion relation and lifetime are measured over the entire Brillouin zone. It is demonstrated that these properties depend strongly on the atomic structure of the films as well as the degree of electronic hybridization with the substrate. We discuss how the complexity of the electronic structure, degree of electronic hybridization and the contribution of different orbitals to the exchange interaction can lead to unexpected behavior of magnon energies. The lifetime of terahertz magnons is found to be a few tens of femtoseconds at low wave vectors, which reduces significantly as the wave vector approaches the Brillouin zone boundary. Based on our results we comment on the damping mechanism of terahertz magnons. Finally, we introduce a way of tailoring the properties of terahertz magnons by engineering the electronic structures.

Topical Talk MA 10.2 Mon 15:30 H23

Theory of spin waves in ultrathin ferromagnetic films — •Roberto Muniz and Antonio Costa — Instituto de Fisica, Universidade Federal Fluminense,Niteroi, RJ 24210-346, Brazil

We review our theoretical studies of spin dynamics in ultrathin ferromagnetic films adsorbed on metallic substrates. Our approach is based on a realistic description of the electronic structure for the substrate/adsorbate combination. Ferromagnetism in the film is driven by on site Coulomb interaction between the d electrons treated in mean field theory, and the spin wave excitations are described by the transverse spin dynamic susceptibility, which is calculated within the random phase approximation. We find the lifetimes of short-wavelength spin excitations in such systems are very short due to their decay to Stoner excitations, in accordance with spin-polarized electron energy-loss spectroscopy (SPEELS) data. We also discuss the influence of spin-orbit coupling on the spin-wave excitation spectra and find that our theory accounts for asymmetries seen in SPEELS studies of spin waves in the bilayer of Fe on W(110).

Topical Talk MA 10.3 Mon 16:00 H23

Magnetic excitations in all metallic nanostructures — •Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

The spins in magnetic nanostructures can be excited, when passing an electric current through them. In the inelastic scattering events, the spin of a hot electron of the current provided by a scanning tunneling microscope may be flipped and angular momentum is transferred to the magnetic system [1]. We used this technique to determine magnon dispersions and life times in thin itinerant magnetic films [2] and to determine the magnetic anisotropy and exchange coupling in atomically assembled magnetic clusters [3]. Finally, we show that the technique is capable to detect spin flips also in rare earth clusters and that the anisotropy as well as the life times of the states in the 4f-systems require a fully relativistic treatment [4].

[1] T. Balashov et al., Phys. Rev. Lett. 97, 187201 (2006), Phys. Rev. B 78, 174404 (2008). [2] C.L. Gao et al., Phys. Rev. Lett. 101, 167201 (2008). [3] T. Balashov et al., Phys. Rev. Lett 102, 257203 (2009). [4] T. Schuh et al., Phys. Rev. B 84, 104401 (2011), Nano Lett. 12, 4805 (2012).

Topical Talk MA 10.4 Mon 16:30 H23

Magnetization dynamics derived from excitations of single magnetic atoms on surfaces — •Alexander Ako Khajetoorians — Hamburg University, Hamburg, Germany

With the development of sub-Kelvin high-magnetic field STM, two complementary methods, namely spin-polarized scanning tunneling spectroscopy (SP-STS) [1] and inelastic STS (ISTS) [2-3], can address single spins at the atomic scale. While SP-STS reads out the projection of the impurity magnetization, ISTS detects the excitations of this magnetization as a function of an external magnetic field. They are thus the analogs of magnetometry and spin resonance measurements pushed to the single atom limit. We have recently demonstrated that it is possible to reliably combine single atom magnetometry with an atom-by-atom bottom-up fabrication to realize complex atomic-scale magnets with tailored properties [4-5]. In this talk, I will address recent developments in probing the spin excitations and magnetization curves of atoms on a multitude of non-magnetic surfaces, and the effects of the electronic structure on the precessional dynamics of the atomic spin. Moreover, I will discuss investigations of the magnetization dynamics [6] of coupled spins as probed with spin-resolved STM techniques and how the relaxation is affected by processes like quantum tunneling and spin-transfer torque. [1] A.A.K., *et al.* , PRL, **106**, 037205 (2011); [2] A. J. Heinrich, *et al.* , Science, **306**, 466 (2004); [3] A.A.K, *et al.* , Nature, **467**, 1084 (2010); [4] A.A.K., *et al.*, Nature Physics, **8**, 497 (2012) [5] A.A.K., *et al.* , Science, **332**, 1062 (2011), [6] A.A.K., *et al.*, Science, in press (2012)

Topical Talk MA 10.5 Mon 17:00 H23

Theory of dynamical magnetic excitations in itinerant nanomagnets — •Samir Lounis — Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany

During the past decades we witnessed an unimaginable progress in the observation and understanding of magnetic structures in nanomagnets. In comparison, our understanding of the dynamics, excitations and switching of magnetism in nanostructures is still in its infancy. In the last years inelastic low-temperature spin-polarised scanning tunneling spectroscopy has been developed and explored producing exciting new insights. In these experiments, the electrons interact with the substrate during the tunneling process, exchange energy and possibly spin angular momentum, leading to inelastic tunneling. To understand, predict and unravel the mechanisms behind these excitations, we developed a method based on first-principles. For instance, during the tunneling process, the dynamical magnetic susceptibility is computed, whose imaginary part gives the density of – , as well as the coupling of tunneling electrons with the spin-excitations that is quantified in terms of a self-energy. An overview of our investigations will be presented: 3*d* adatoms deposited on several metallic surfaces: Cu(100), Cu(111), Ag(111) and Pt(111) with a focus on the impact of adatoms atomic number, nature of the substrate, details of the electronic hybridization as well as the decay of the electronic signal into vacuum.

Work supported by the HGF-YIG Programme FunSiLab – Functional Nanoscale Structure Probe and Simulation Laboratory (VH-NG-717).

MA 11: ThyssenKrupp Electrical Steel Dissertationspreis 2013 der AG Magnetismus

Ziel dieses jährlich durch die Thyssen-Krupp Electrical Steel Ag unterstützten Preises ist die Anerkennung herausragender Forschung im Fachverband Magnetismus im Rahmen einer Doktorarbeit und deren exzellente Vermittlung in Wort und Schrift. Nominiert wurden wissenschaftlich herausragende Dissertationen auf dem Fachgebiet Magnetismus in Theorie, Grundlagen und/oder Anwendungen, die im Jahr 2011 oder 2012 an einer deutschen Hochschule abgeschlossen wurden.

Auswahlverfahren: Ein von der AG Magnetismus eingesetztes Preiskomitee ermittelte unter den Einsendungen bis zu vier Finalisten, die hier in dieser Sitzung einen 20 min. Vortrag mit Diskussion über ihre Arbeit halten. Unmittelbar nach dem Symposium wählt das Preiskomitee den (die) Sieger(in), der (die) noch auf der Tagung bekannt gegeben wird. Das Preisgeld beträgt 1.000 EUR.

Aus den eingegangenen Vorschlägen wurden die folgenden Kandidaten in die engere Wahl genommen.

Time: Monday 12:15–13:55 Location: H3

MA 11.1 Mon 12:15 H3

Direct measurement of the spin polarization by tunneling spectroscopy with superconducting electrodes — •Oliver Schebaum — Thin Films and Physics of Nanostructures, Physics Department, Bielefeld University, Germany

Spinelectronics utilize the spin degree of freedom of electrons, which is neglected by conventional electronics. One promising spinelectronic device is the magnetic tunnel junction (MTJ). The spin polarization of the tunneling current in an MTJ can be altered by the magnetic electrodes as well as the incorporated tunnel barrier material. Tunnel junctions with a unified layer stack were prepared for three different barriers. In these systems, the tunnel magnetoresistance (TMR)ratios at optimum annealing temperatures were found to be 65% for Al2O3, 173% for MgO, and 78% for MgO-Al2O3 composite tunnel barriers. The similar TMR ratios of the tunnel junctions containing alumina provide evidence that coherent tunneling is suppressed by the alumina layer in the composite tunnel barrier [1]. Furthermore, we prepared tunnel junctions with one ferromagnetic and one superconducting Al-Si electrode. Pure cobalt electrodes were compared with a Co-Fe-B alloy and the Heusler compound Co2FeAl. The polarization of the tunneling electrons was determined using the Maki-Fulde-model and is discussed along with the spin-orbit scattering and the total pair-breaking parameters. The junctions were postannealed at different temperatures to investigate the symmetry filtering mechanism responsible for the giant TMR ratios in Co-Fe-B/MgO/Co-Fe-B junctions.[2,3]

[1] O. Schebaum, V. Drewello, A. Auge, G. Reiss, M. Münzenberg,H. Schuhmann, M. Seibt and A. Thomas, J. Magn. Magn. Mat. 323 (2011) 1525-1528

[2] O. Schebaum, D. Ebke, A. Niemeyer, G. Reiss, J.S. Moodera and A. Thomas, J. Appl. Phys. 107 (2010) 09C717

[3] O. Schebaum, S. Fabretti, J.S. Moodera and A. Thomas, New J. Phys. 14 (2012) 033023

MA 11.2 Mon 12:40 H3

Tailoring the magnetic vortex nucleation conditions in soft magnetic disks by means of introducing a — •Norbert Martin — Helmholtz-Zentrum Dresden-Rossendorf, 01099 Dresden

N. Martin Magnetic vortex structures are a promising candidate for magnetic data storage hence two bits can be stored per vortex, that is the chirality of the in plane magnetization and the orientation of the vortex core. This allows a higher data storage density. There are, however, lower limits in the size of magnetic elements in which a vortex can nucleate. One issue is thereby the magnetic field which is necessary in order to nucleate a vortex.

In the presented work a method is developed in order to decrease the nucleation field in a defined way by means of introducing a geometric asymmetry in the out of plane direction. The so caused decrease in the nucleation field is shown by micromagnetic modeling and experiments.

The asymmetry is introduced experimentally by masking a Permalloy thin film with a closely packed monolayer of nanospheres and subsequently irradiating the masked film with ions. The formation of magnetic vortices in such structures is proved by magneto-optic investigations and magnetic force microscopy. According to this dense arrays of small disks with magnetic vortices can be formed, which opens a way to higher data storage density.

MA 11.3 Mon 13:05 H3

Magnetoelectric coupling at metal surfaces — •Lukas Gerhard — Institute of Nanotechnology, Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

Magnetoelectric coupling offers the possibility to change the magnetic state of a material by an applied electric field. In the past, research in this field has focused on insulating materials such as complex multiferroic oxides because in bulk metallic systems, any external electric field is screened by the formation of a surface charge. In the topmost atomic layer of a metallic surface, however, this surface charge leads to small vertical displacements of the atomic cores. In thin films, this change of the interlayer distance in turn may lead to a modification of the magnetic order. In the framework of this thesis, we demonstrated electric-field induced reproducible switching of the magnetic order of a metallic system between two metastable states [1]. Strong magnetoelectric coupling on a few square nanometers was demonstrated at the surface of iron nanoislands on a copper substrate using the electric field of a scanning tunneling microscope. Electric-field induced phase transitions observed in two other systems show that magnetoelectric coupling is a fundamental effect in metallic magnetic thin films that may lead to the development of high-density non-volatile information storage devices made of metals.

[1] Magnetoelectric coupling at metal surfaces, L. Gerhard et al, Nature Nanotechnology 5 (2010)792-797

MA 11.4 Mon 13:30 H3

Spin-Resolved Studies of Individual Adsorbed Molecules with Sub*molecular Spatial Resolution — •Jens Brede — Institute of Applied Physics, University of Hamburg

We have investigated the spin- and energy-dependent tunneling through single molecules adsorbed on ferromagnetic thin films, spatially resolved at a sub-molecular level by low temperature spin-polarized scanning tunneling microscopy (SPSTM). In the case of cobalt coordinated Pc (CoPc) molecules the metal ion as well as the organic ligand exhibit a significant energy and spin dependence of STM images: Interestingly, the spin-majority dominated current flow from the organic periphery is in contrast to the spin-minority dominated tunneling current flow from the surrounding ferromagnetic Fe film. The observed inversion of the local spin polarization can explain the puzzling negative GMR values, which have been observed and controversially discussed in the field of molecular spin valves [1,2]. Thereby, our work tackles central aspects which are essential for understanding and designing new molecular spintronic devices.

More recently, phthalocyanine based single-molecule magnets (SMMs) were studied on ferromagnetic nanostructures by SPSTM as promising model systems for spintronic devices, quantum computing, and data storage at the nanoscale. In particular, we revealed the spin-dependent properties of SMMs with the highest reported blocking temperature bis(phthalocyaninato)terbium(III) (TbPC2). Individual spin split molecular orbitals were resolved for the first time with sub-molecular spatial resolution and the magnitude of the substrate induced exchange splitting was determined by spin-resolved tunneling spectroscopy. The unique insight offered by our SPSTM experiments highlights the importance of resolving spin-dependent molecular properties in atomically well-defined environments on a submolecular scale.

[1] Xiong et al., Nature 427, 821 (2004) [2] Jiang et al., Phys. Rev. B 77, 035303 (2008)

MA 12: Focus Session: Terahertz Spintronics

Organizer: M. Münzenberg (Georg-August-University Göttingen)

Currently a new window has opened up in working with spin-polarized current bunches with a width of 100 fs from different directions. Generated by the non-equilibrium electrons, these can be treated by superdiffusive transport of magnetization. Experiments demonstrate a new way of manipulation of the spin bunches by non-magnetic materials, acting as a spin localizer, and their impact on the magnetization itself - paving the way for a THz spintronics.

Time: Tuesday 9:30–12:00 Location: H10

Topical Talk MA 12.1 Tue 9:30 H10

Ultrafast magnetization enhancement in metallic multilayers driven by superdiffusive spin current — •Roman Adam[1], Chan La-O-Vorakiat[2], Marco Battiato[3], Dennis Rudolf[1], Justin M. Shaw4[4], Emrah Turgut[2], Pablo Maldonado[3], Stefan Mathias[5], Patrik Grychtol[2], Hans T. Nembach[4], Thomas J. Silva[4], Martin Aeschlimann[5], Henry C. Kapteyn[2], Margaret M. Murnane[2], Claus M. Schneider[1], and Peter M. Oppeneer[3] — [1]Peter Grünberg Institut PGI-6, Research Centre Jülich, 52425, Germany — [2]Department of Physics and JILA, University of Colorado, Boulder, CO 80309-0440, USA — [3]Department of Physics and Astronomy, Uppsala University, Sweden — [4]Electromagnetics Division, NIST, Boulder, CO 80305-3328, USA — [5]University of Kaiserslautern and Research Center OPTIMAS, 67663, Kaiserslautern, Germany

Combining the femtosecond time resolution with element selectivity in pump-probe experiment we studied the magnetic response of Ni/Ru/Fe trilayers. By exciting the trilayer with infrared laser light we observed the ultrafast magnetization response in the Ni and Fe layers separately using synchronized extreme ultraviolet probe pulses tuned to the 3p absorption edges of Ni and Fe. Following the optical excitation, we detected both magnetization quenching as well as, an unexpected magnetization enhancement in the buried Fe layer. We ascribe the observed response to the optically generated superdiffusive spin currents between the layers [1,2].

[1] D. Rudolf, et al. Nature Commun. 3, 1037 (2012)
[2] M. Battiato, et al. Phys. Rev. Lett. 105, 027203 (2010)

Topical Talk MA 12.2 Tue 10:00 H10

New frontiers of ultrafast spin manipulation: femtosecond spin superdiffusion — •Marco Battiato — Uppsala University, Uppsala, Sweden

The origin of the ultrafast demagnetization has been a mystery for long time. Recently an approach based on spin dependent electron diffusion has been proposed. In the theoretical work the spin dependent electron transport in the femtosecond timescale had been accurately modeled and predicted as responsible for the ultrafast demagnetization.

It has been shown that 1) the femtosecond transport is within the more general regime of superdiffusion; 2) spin bunches with velocities higher than the Fermi velocity can be launched from a ferromagnetic material and 3) can be used to strongly manipulate the magnetization of distant layers. The newest experimental findings are proving the model by showing uncontrovertibly the sign of spin transport and validating the model*s unexpected predictions (see other talks within the symposium on THz spinelectronics).

The impact of these new discoveries goes beyond the field of ultrafast demagnetization. It shows how spin information can be, not only manipulated but most importantly transferred at unprecedented speeds. This new discovery lays the basis for femtosecond spintronics.

Topical Talk MA 12.3 Tue 10:30 H10

Engineering of terahertz spin currents in magnetic heterostructures — •T. Kampfrath[1], M. Battiato[2], P. Maldonado[2], G. Eilers[3], J. Nötzold[1], S. Mährlein[1], V. Zbarsky[3], I. Radu[4], F. Freimuth[5], Y. Mokrousov[5], S. Blügel[5], M. Wolf[1], P. M. Oppeneer[2], and M. Münzenberg[3] — [1]Fritz Haber Institute, Berlin, Germany — [2]University of Uppsala, Sweden — [3]University of Göttingen, Germany — [4]BESSY II, Helmholtz Center Berlin, Germany — [5]Forschungszentrum Jülich, Germany

One goal of spintronics research is the controlled transport of spin-polarized electron bunches through a solid, preferably at frequencies reaching the so far unexplored terahertz (THz) regime. Here, we show, by experiment and theory, that femtosecond spin currents can be manipulated by using suitable magnetic heterostructures. A femtosecond laser pulse is employed to trigger spin transport from a ferromagnetic Fe thin film into a nonmagnetic cap layer with either low (Ru) or high (Au) electron mobility. To detect the transient spin current $j_s(t)$, we make use of the inverse spin Hall effect that converts $j_s(t)$ into a charge current $j_c(t)$. By sampling the subsequently emitted electromagnetic THz transient in the time domain, the temporal structure of the femtosecond spin current can be determined. We find that the Fe-Ru bilayer yields a considerably longer $j_s(t)$ because electrons are injected in Ru d states that have a much lower mobility than Au sp states. Thus, THz spin current pulses can be shaped by tailoring magnetic heterostructures, which may open a route to engineering high-speed spintronic devices.

Topical Talk MA 12.4 Tue 11:00 H10

Ultrafast spin dynamics induced by laser-generated spin currents in metallic multilayers probed by non-linear magneto-optics — •Alexey Melnikov — Fritz-Haber-Institut der MPG, Abt. Phys. Chemie, Faradayweg 4-6, 14195 Berlin

The ultrafast spin dynamics (SD) induced by a transport of spin-polarized carriers is a hot topic motivated by the fundamental interest in magnetic excitations and applications like spintronics and data storage. To understand underlying elementary processes typically occurring on femtosecond time scales, we have developed a time-of-flight-like approach that probes the SD induced by hot carriers (HC) and demonstrated a spin polarized HC transport through an epitaxial Au/Fe/MgO(001) structure. Optical second harmonic generated at the Au surface monitors the transient surface HC density and spin polarization. Using a back pump-front probe configuration, we establish that HC induced in Fe by the pump laser pulse can form a nearly ballistic spin current (SC) in the Au layer which works as spin-selective HC retarder/attenuator. First experiments on the SD induced by femtosecond SC pulses in Fe/Au/Fe/MgO(001) structures demonstrate the spin transfer between the two Fe layers and the Au spacer serving as a spin sink. We discuss the key role of spin-dependent interface scattering of HC in the excited SD and consider the extension of our experimental approach to the investigation of spin transfer torque effects induced by femtosecond SC pulses. Financial support by the DFG through ME 3570/1-1 is acknowledged.

Topical Talk MA 12.5 Tue 11:30 H10

Ultra-fast spin currents in transparent magnetic tunnel junctions — •Andy Thomas — Universität Bielefeld, Universitätsstrasse 25, 33615 Bielefeld

Ultra-fast spin current can also be excited in magnetic tunnel junctions (MTJs). We prepared MTJs with tunnel magnetoresistance (TMR) ratios of up to 320% at room temperature with 2.4 nm magnesia tunnel barriers. Current induced magnetic switching (3×10^6 A/cm^2) was observed for MTJs with 1.1 nm MgO barrier while maintaining a TMR ratio of 100%. We further reduced the barrier thickness and we were able to achieve 60% TMR ratio for 3 ML ultra-transparent MgO tunnel barriers. In these junctions, low switching currents can be realized. Furthermore, currents can be generated using a femtosecond laser and temperature gradients of 10 K/nm are possible across the tunnel barrier. These ultra-fast pulses generate spin-polarized charge current bunches which can be modified via the TMR effect of the junctions.

[1] A. Mann et al., Phys. Rev. X 2 (2012) 041008
[2] M. Walter et al., Nature Mater. 10 (2011) 742
[3] G. M. Müller et al., Nature Mater. 8 (2009) 56

MA 13: Graphene - Electronic Properties and Transport 2 (jointly with DS, HL, MA, and O)

Time: Tuesday 9:30–12:45 Location: H17

MA 13.1 Tue 9:30 H17

Transport properties of high-quality reduced graphene oxide — •Michael Enzelberger[1], Siegfried Eigler[2], Philipp Hofmann[1], Stefan Grimm[2], Andreas Hirsch[2], and Paul Müller[1] — [1]Department of Physics and Interdisciplinary Center for Molecular Materials, Universität Erlangen-Nürnberg — [2]Department of Chemistry and Pharmacy, and Institute of Advanced Materials and Processes (ZMP), Universität Erlangen-Nürnberg

Chemical production of graphene, especially reducing graphene oxide has gained a lot of interest in recent years. Yet the transport properties of such materials are usually not compatible to those of graphene.

We have found a way to overcome this problem using a modification of the standard Hummer's method. Single flakes of reduced graphene oxide have been investigated. The graphene oxide was deposited onto a SiO_2/Si substrate and subsequently reduced using hydrogen iodine. The resulting reduced graphene oxide samples were patterned by electron beam lithography. We have characterized the quality of the samples by combining Raman spectroscopy and Hall mobility measurements in magnetic fields up to $14\,T$ and temperatures down to $0.3\,K$.

High-quality samples had a Raman D/G ratio of better than 1 and showed Hall mobilities exceeding 1000 cm^2/Vs. This is nearly two orders of magnitude higher than what is known for standard reduced graphene oxide. The best samples even show Shubnikov-de Haas oscillations and Hall plateaus.

MA 13.2 Tue 9:45 H17

Magnetoresistance of Nanocrystalline Graphene — •Daniel Steininger[1], Paul Linsmaier[1], Ina Schneider[1], Christoph Strunk[1], Matthias Büenfeld[2], Nils-Eike Weber[2], Andrey Turchanin[2], Miriam Grothe[3], and Thomas Weimann[3] — [1]Institute for Experimental and Applied Physics, University of Regensburg, Universitätsstr. 31, D-93053 Regensburg, Germany — [2]Faculty of Physics, University of Bielefeld,Universitätsstr.25, D-33615 Bielefeld, Germany — [3]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

We report on the magnetotransport in Hall bar structures of nanocrystalline graphene. The graphene sheets were prepared by electron-beam-induced cross-linking and subsequent pyrolysis of aromatic self-assembled monolayers [1]. The I-V characteristics show considerably non-linear behaviour at low temperatures. One low resistive sample ($\approx$ 200 kOhm/sq at T = 4 K) shows positive magnetoresistance values up to + 20 % in the perpendicular magnetic field for temperatures below 6 K, while above this temperature the magnetoresistance becomes negative. Measurements of the transversal voltage in the linear regime exhibit anomalous behaviour which cannot be explained by the conventional Hall effect. If the magnetic field is aligned parallel to the graphene sheet the magnetorestance exhibits large positive values up to + 300 %. Measurements on a highly resistive sample ($\approx$ 30 MOhm/sq at T = 4 K) reveal a non-monotonic behaviour of the magnetoresistance in a perpendicular magnetic field.

[1] A. Turchanin et al., ACS Nano 5 (2011) 3896-3904.

MA 13.3 Tue 10:00 H17

Quantum Monte Carlo Study of Edge-State Magnetism on Chiral Graphene Nanoribbons — Michael Golor[1], Thomas C. Lang[1,2], and •Stefan Wessel[1] — [1]Institute for Theoretical Solid State Physics, RWTH Aachen — [2]Department of Physics, Boston University

We investigate the edge-state magnetism of chiral graphene nanoribbons using projective Quantum Monte Carlo (QMC) simulations and a self-consistent mean-field approximation of the Hubbard model. Previous QMC simulations support edge-state ferromagnetism in sufficiently wide zigzag terminated ribbons. We extended these calculations to include the class of chiral graphene nanoribbons and investigate the influence of chirality and ribbon width on spin-spin correlations. The static magnetic correlations are found to rapidly increase with the width of the ribbons for all chiralities, such that already for ribbons of moderate widths we observe a strong trend towards mean-field-type ferromagnetic correlations along the edges. We extract dynamical edge state signatures which can be used to detect edge-state magnetism by scanning tunneling microscopy.

MA 13.4 Tue 10:15 H17

Even-odd effects in NSN scattering problems: Application to graphene nanoribbons — •Francois Crepin[1], Hans Hettmansperger[1], Patrik Recher[2], and Bjoern Trauzettel[1] — [1]Institute for Theoretical Physics and Astrophysics, University of Wuerzburg, 97074 Wuerzburg, Germany — [2]Institute for Mathematical Physics, TU Braunschweig, 38106 Braunschweig, Germany

We study crossed Andreev reflection (CAR) of electrons or holes in normal metal-superconductor-normal metal junctions and highlight some very strong effects of the underlying lattice. In particular, we demonstrate that for sharp interfaces and under certain, albeit generic, symmetry conditions, the CAR probability exactly vanishes for an even number of atoms in the superconducting region. This even-odd effect applies notably to NSN junctions made of graphene nano-ribbons with armchair edges and for zigzag edges with somewhat more restrictive conditions. We analyze its robustness towards smoothing of the boundaries or doping of the sample.

MA 13.5 Tue 10:30 H17

Efficient quantum transport simulation for bulk graphene heterojunctions: Klein backscattering revisited — •Ming-Hao Liu and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany

The quantum transport formalism based on tight-binding models is known to be powerful in dealing with a wide range of open physical systems subject to external driving forces but is, at the same time, limited by the memory requirement's increasing with the number of atomic sites in the scattering region. Here we demonstrate how to achieve an accurate simulation of quantum transport feasible for experimentally sized bulk graphene heterojunctions at a strongly reduced computational cost [1]. Without free tuning parameters, we show excellent agreement with recent experiments on Klein backscattering [2,3].

[1] M.-H. Liu and K. Richter, Phys. Rev. B **86**, 115455 (2012).
[2] A. F. Young and P. Kim, Nat. Phys. **5**, 222 (2009).
[3] S.-G. Nam, D.-K. Ki, J. W. Park, Y. Kim, J. S. Kim, and H.-J. Lee, Nanotechnology **22**, 415203 (2011).

MA 13.6 Tue 10:45 H17

Combined effect of vacancies and strain on the conductance of graphene nanoribbons — •Thomas Lehmann, Dmitry A. Ryndyk, and Gianaurelio Cuniberti — Institute for Materials Science, Dresden University of Technology, 01062 Dresden, Germany

The understanding and engineering of electron properties of carbon-based nanostructures, in particular graphene nanoribbons, is an important challenge for modern theory of nanoscale systems. We investigate the influence of vacancy defects and uniaxial strain on the electronic transport properties of intermediate-scale graphene nanoribbons using the numerical approach based on the semi-empirical or ab initio based tight-binding model, the Landauer-Büttiker formalism and the recursion method for Green functions. We calculate the transmission of graphene nanoribbons in the quantum coherent regime with different types and concentration of defects. Further, we apply uniform planar tension to non-ideal graphene ribbons with randomly distributed and oriented single and double vacancies and Stone-Wales defects. Since transport characteristics of graphene are found to be very sensitive to edge termination and aspect ratio and it has been shown that energy gaps can emerge under critical strain, the interplay of both effects needs to be studied.

15 min. break

MA 13.7 Tue 11:15 H17

Spin conductance of diffusive graphene nanoribbons — •Jan Bundesmann[1], Ming-Hao Liu[1], Inanc Adagideli[2], and Klaus Richter[1] — [1]University of Regensburg, Regensburg, Germany — [2]Sabanci University, Istanbul, Turkey

Graphene, when cut along a zigzag edge, shows a strongly increased density of states at energies close to the charge neutrality point. The electron states that are the source of this increased DOS are pseudospin-polarized, i.e. they occupy mainly one sublattice, while their wavefunction decays exponentially from the zigzag edge.

In such systems one expects magnetic ordering which anifests as an antiferromagnetic alignment of the two sublattices. Due to the pseudospin polarization of the states finite local magnetic moments appear along the edges.

We investigate how the formation of these local magnetic moments influences charge and spin transport in graphene. It will be shown how this can lead to a finite spin conductance of a single graphene nanoribbon and that within the localized transport regime the spin conductance fluctuations exhibit universal behaviour in the sense that they don't depend on the exact modelling of the magnetization and even a large amount of edge roughness does not lead to deviations from this universal behaviour.

MA 13.8 Tue 11:30 H17

Superlattice Effects on Electronic- and Transport Properties of Nanomaterials — •Fedor Tkatschenko, Viktor Krueckl, and Klaus Richter — Universität Regensbug, Germany

As recently discoverded by various groups [1,2] the electronic properties of two dimensional systems such as graphene show interesting characteristics in presence of superlattices including the emergence of extra Dirac points accompanied by an anisotropic velocity renormalization. Other interesting effects are Bloch-oscillations in presence of resonant Zener tunneling [3] giving rise to a negative differential conductance in the current voltage characteristics.

We focus on a scalar superlattice system extended by a constant mass term which opens a gap between the valance and conduction band in the minibandstructure. Analytical calculations within the effective Dirac model show that it is possible to tune the energy gap by variation of the superlattice amplitude. By additional numerical calculations based on the tight-binding model we confirm the analytical results.

[1] L. Brey and H. Fertig, Phys. Rev. Lett. **103**, 046809 (2009)
[2] M. Barbier, P. Vasilopoulos, and F. Peeters, Phys. Rev. B **81**, 075438 (2010)
[3] V. Krueckl and K. Richter, Phys. Rev. B **85**, 115433 (2012)

MA 13.9 Tue 11:45 H17

Hot Spots and Boundary Conditions in the Quantum Hall Effect — •Tobias Kramer — Universitaet Regensburg, Inst. Theor. Physik, Germany

I discuss the influence of metallic boundary conditions due to the device contacts on the observation and current distribution in the quantum Hall effects. The current density differs in the presence of hot-spots completely from the often assumed edge-state transport picture. A model for transport in graphene [1] based on the self-consistent solution of the classical Hall effect [2] is put forward.

[1] T. Kramer, C. Kreisbeck, V. Krueckl, E. Heller, R. Parrott, and C.-T. Liang, Phys. Rev. B **81**, 081410(R) (2010)
[2] T. Kramer, V. Krueckl, E. Heller, and R. Parrott, Phys. Rev. B **81**, 205306 (2010)

MA 13.10 Tue 12:00 H17

Current resonances in graphene with time dependent potential barriers — Sergey E. Savel'ev[1], •Wolfgang Häusler[2], and Peter Hänggi[2] — [1]Department of Physics, Loughborough University, United Kingdom — [2]Universität Augsburg, Germany

A method is derived to solve the massless Dirac-Weyl equation describing electron transport in a mono-layer of graphene with a scalar potential barrier $U(x,t)$, homogeneous in the y-direction, of arbitrary x- and time dependence. Resonant enhancement of both electron backscattering and currents, across and along the barrier, is predicted when the modulation frequencies satisfy certain resonance conditions. These conditions resemble those for Shapiro-steps of driven Josephson junctions. Surprisingly, we find a non-zero y-component of the current for carriers of zero momentum along the y-axis.

[1] Sergey E. Savel'ev, Wolfgang Häusler, Peter Hänggi, Phys. Rev. Lett. **109**, 226602 (2012).

MA 13.11 Tue 12:15 H17

Mie scattering analogon in graphene: particle confinement, scattering resonances, and Fano effect — •Rafael Leslie Heinisch, Christian Schulz, Franz Xaver Bronold, and Holger Fehske — Institut für Physik, Universität Greifswald

We study the scattering of an incident electron by a circular step in a graphene monolayer in analogy to Mie scattering of light by a sphere. Klein tunnelling results in the absence of backscattering and often entails enhanced forward scattering. For low electron energies we identify sharp resonances originating from quasi-bound states at the dot. The energy and dot radius dependent temporary electron trapping significantly increases the electron density in the dot and induces a vortex pattern in the current field. The angle-resolved scattering exhibits Fano resonances which - counter-intuitive for Klein tunnelling - dramatically suppress forward scattering.

This work is supported by the DFG through SPP 1459.

MA 13.12 Tue 12:30 H17

Mechanical strain on graphene nanoribbons in contact with metal electrodes — •Arezoo Dianat, Dmitry A. Ryndyk, and Gianaurelio Cuniberti — Institute for Materials Science, Dresden University of Technology, 01062 Dresden, Germany

Carbon-based materials are recently of great interest for electronic devices. One of the important issues in graphene based nanoelectronics is to control its electronic and transport properties. The manipulation of electronic properties of graphene nanoribbons (GNR) has been suggested via mechanical strain, vacancies and chemical doping. From modeling point of view, few studies have been reported to investigate the electronic properties of mechanically stretched GNR in a contact with metal electrodes. In this work, we aim to elucidate the combined effects of mechanical strain and the role of metal contact area on the electronic and transport properties of GNR.

The structural and electronical properties of stretched GNR on Nickel and Palladium surfaces with different contact area and suspended strained graphene junction between metal electrodes are investigated by means of density functional theory using Vienna Ab initio Simulation Package (VASP). The structure stability as well as stress-strain curve are analyzed for several strain coefficients.

MA 14: Micromagetic Simulation and Electron Theory of Magnetism

Time: Tuesday 9:30–12:00 Location: H23

MA 14.1 Tue 9:30 H23

Notes on the Gilbert equation for dissipative magnetization dynamics — •Manfred Fähnle, Frank Schweiner, and Christian Illg — Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany

The simplest equation of motion for dissipative magnetization dynamics $\vec{M}(\vec{r},t)$ close to the adiabatic limit (timescale ns - ca 100 ps) which describes precession around an effective field and damping (by a local term $\vec{M}\times\alpha\frac{\partial\vec{M}}{\partial t}$ with a constant damping scalar α) is Gilbert's equation. Various types of theories have shown that in general the damping is nonlocal and anisotropic, described by a matrix $\underline{\underline{\alpha}}(\vec{r},\vec{r}^{\,\prime};\vec{M}(\vec{r}^{\,\prime\prime}))$ which depends on the magnetization configuration $\vec{M}(\vec{r}^{\,\prime\prime})$ at all sites $\vec{r}^{\,\prime\prime}$ in the sample. Furthermore, for very fast dynamics an inertial damping term proportional to $\frac{\partial^2\vec{M}}{\partial t^2}$ should be added. The Gilbert equation is a partial differential equation and has to be supplemented by boundary conditions formulated in the most general way by Guslienko and Slavin. The question is discussed whether those boundary conditions have to be applied also for numerical simulations based on Gilbert's equation. A tensorial Green's function is constructed for the solution of the linearized Gilbert equation.

MA 14.2 Tue 9:45 H23

Micromagnetic analysis of nucleation and pinning processes in the intermetallic compound MnBi — Dagmar Goll[1] and •Helmut Kronmüller[2] — [1]Aalen University, Materials Research Institute, Aalen — [2]Max-Planck-Institute for Intelligent Systems, Stuttgart

The low temperature phase (LTP) of the binary intermetallic compound MnBi shows extraordinary magnetic properties in the temperature range up to 600 K. An anisotropy constant of 2.2 MJ/m^3 at 400 K and a large magnetic moment of 3.6 Bohr magnetons of Mn atoms

predestinates the low temperature phase (LTP) of MnBi as a high temperature permanent magnet. Depending on the type of microstructure the hysteresis loops are governed either by nucleation or domain wall pinning processes. A micromagnetic analysis of the temperature dependence and of the angular dependence of the coercive field allows a decision whether the nucleation or the pinning mechanism governs the hysteresis loop. In the case of the intermetallic compound MnBi and other supermagnets in general the Stoner-Wohlfarth-Theory has to be expanded with respect to higher anisotropy constants and microstructural effects, as misaligned grains, and the role of grain surfaces with reduced anisotropy constants. Taking care of these effects leads to a quantitative interpretation of recent experimental results obtained for nanocrystalline magnets [1]. Nucleation hardened nanocrystalline magnets with coercive fields up to 2.5 Tesla at 500 K are found to be superior to the pinning hardened multiphase magnets of MnBi. [1] J.B. Yang et al., Appl. Phys. Letters 99, 062505 (2011).

MA 14.3 Tue 10:00 H23

Multiscale study of Bloch points and their dynamics — •Christian Andreas[1,2], Attila Kákay[1], and Riccardo Hertel[2] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich GmbH, D-52428 Jülich, Germany — [2]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg, CNRS UMR 7504, Strasbourg, France

Compared to domain walls and (anti-) vortices, little is known about the dynamic properties of Bloch points (BPs) [1,2]. BPs are fundamental magnetic structures occurring, e.g., in vortex-type domain walls in nanocylinders [3] or transient when vortex cores switch [4]. They are difficult to treat in micromagnetism because of their maximally inhomogeneous structure and a singularity of the exchange energy density. This violates the basic micromagnetic assumption of smooth variations on atomistic length scales. The problem can be solved by using a Heisenberg model. In order to simulate a BP embedded into a mesoscopic domain structure we developed a multiscale code with a seamless coupling between an atomistic region of interest (ROI) and the magnetization calculated with our finite-element code TetraMag. By moving the ROI we can trace BPs during switching processes. We demonstrate the compatibility of the multiscale model with micromagnetic results and present examples of simulated BP dynamics.
[1] E. Feldtkeller, Z. Angew. Phys. 19, 530 (1965)
[2] W. Döring, J. Appl. Phys. 39, 1006 (1968)
[3] R. Hertel and J. Kirschner, J. Magn. Magn. Mater. 3, L291 (2004)
[4] R. Hertel et al., Phys. Rev. Lett. 11, 117201 (2007)

MA 14.4 Tue 10:15 H23

Multiple-q states in classical triangular-lattice Heisenberg antiferromagnet with frustrated interactions — •Andrey Leonov and Maxim Mostovoy — Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

In geometrically frustrated magnets with the triangular lattice, the interplay of nearest-(J1) and next-nearest neighbor (J2) interactions can destabilize the homogeneous magnetic structure and induce diverse incommensurate multiple-q states. Within the basic J1-J2 exchange Hamiltonian with the Zeeman term, the single-q state is the ground state, whereas the double-q (2Q) and the triple-q (3Q) states are only metastable solutions [1]. In this contribution we show that additional magnetic couplings can render the 2Q and 3Q states into thermodynamically stable phases. We also show that at low temperatures the 3Q state in the frustrated triangular antiferromagnet is similar to the skyrmion crystal lattice recently observed in non-centrosymmetric magnets (e.g. MnSi and FeGe), but has a higher degree of degeneracy and the number of Goldstone modes. [1] T. Okubo et al., Phys. Rev. Lett. 108, 017206 (2012); [2] A. Leonov, Ph.D thesis, Dresden University of Technology, Dresden (2012).

MA 14.5 Tue 10:30 H23

Low temperature magnetic phase of bulk MnSi: An *ab initio* study — •Giovanna Lani, Gustav Bihlmayer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

The magnetic phase diagram of bulk MnSi has been the object of several experimental and theoretical studies over the years, recently receiving renewed interest, due to the debated nature of its magnetic order around the Curie temperature upon the application of a small magnetic field. On the other hand, it is well established from neutron scattering experiments, that at low temperature MnSi exhibits helical spin spiral order along the ⟨111⟩ direction. Employing density functional theory calculations based on the full-potential linearized augmented plane wave method as implemented in the `FLEUR` code [1], we carry out a comprehensive study of the exchange interactions in this system and present here our preliminary results. Working in the adiabatic approximation, we evaluate the Heisenberg exchange parameters (J_{ij}) and compare their behavior with the one expected by the RKKY interaction for ferromagnets. The J_{ij} coefficients are then employed to calculate the energy of spin spirals with different wave vectors. Finally we estimate the Curie temperature via mean field approximation and Monte Carlo calculations and compare it with previous calculations and available measurements.
[1] www.flapw.de

MA 14.6 Tue 10:45 H23

Magnetic phase transitions of ferromagnetic and antiferromagnetic alloys from first principles — •Konstantin Tillmanns, Phivos Mavropoulos, and Stefan Blügel — Peter Grünberg Institut and Institute forAdvanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We investigate a wide spectrum of ordered and disordered magnetic alloys concerning their magnetization, half metallicity and Curie/Néel temperature using an *ab initio* approach. We employ the Korringa-Kohn-Rostoker (KKR) Green function method [1] for the electronic structure and the method of infinitesimal rotations [2] for the exchange coupling parameters. These are derived both from the ground state and from the disordered local moment (DLM) state [3] and utilized in a Heisenberg model whose thermodynamical properties are studied by Monte Carlo simulations. By this we locate the magnetic phase transition. We furthermore focus on a comparison of the critical temperatures calculated by the different theoretical approaches (ground-state and DLM starting points) with experimental data.
[1] N. Papanikolaou, R. Zeller, and P.H. Dederichs, J. Phys. Condens. Matter **14**, 2799 (2002); H. Ebert, D. Ködderitzsch and J. Minár, Rep. Prog. Phys. **74**, 096501 (2011); see also `http://www.kkr-gf.org`.
[2] A.I. Liechtenstein et. al., J. Magn. Magn. Mater. **67**, 65 (1987).
[3] H. Akai and P.H. Dederichs, Phys. Rev. B **47**, 8739 (1993).

MA 14.7 Tue 11:00 H23

Magnetic systems at elevated temperatures by relativistic disordered local moments theory — •Danny Böttcher[1,2] and Jürgen Henk[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

The mismatch of experimentally and theoretically observed, temperature-dependent magnetic properties, in particular the magnetic moment and the Curie temperature, requires improvements in first-principles calculations. The magnetism of ferromagnets at elevated temperatures is described within a relativistic disordered local moments theory. The fluctuation strength of the local magnetic moments at a given temperature is obtained from first-principles calculations, taking into account the temperature-dependent distribution function of the local moment directions and spin-orbit coupling. We introduce to the approach and apply it to bulk Fe, Co, and Ni. Agreement of the magnetization versus temperature dependence with our Monte-Carlo method is found in the entire temperature range of $0 < T < T_c$.

MA 14.8 Tue 11:15 H23

Localization of magnetocrystalline anisotropy energy: Answering the Unanswerable — •Ondrej Sipr[1], Sven Bornemann[2], Hubert Ebert[2], and Jan Minar[2] — [1]Institute of Physics ASCR, Cukrovarnicka 10, Prague, Czech Republic — [2]Department Chemie, Ludwig-Maximilians-Universitat Munchen, Munchen, Germany

Magnetocrystalline anisotropy is one the of the key properties that determine the practical applicability of various systems containing magnetic atoms and clusters. Calculating it from first principles is a great challenge both numerically and fundamentally. However, to get a full picture, one needs not only to calculate the magnetocrystalline anisotropy energy (MAE) as accurately as possible but also to understand intuitively which factors effect it in various ways. For ad-atoms and films, one of the hotly debated issues in this context is what is the role of the substrate or, in other words, whether the MAE comes from only the magnetic ad-atoms or whether there is also a sizable contribution from the substrate.

In principle, the question about the localization of the MAE cannot be answered because energy is not an extensive quantity. However,

by a carefull choice of model systems where the spin-orbit coupling and the exchange field are selectively switched on and off, one can still get a well-defined insight into how different atoms contribute to the "non-localizable" MAE. We illustrate this approach by inspecting the MAE for Co ad-atoms and monolayers on Pd, Pt, Cu, Ag, and Au (111) surfaces calculated under various schemes.

MA 14.9 Tue 11:30 H23

Construction of transition matrix elements for the scattering of crystal electrons at magnons — •Michael Haag, Christian Illg, and Manfred Fähnle — Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany

The scattering of crystal electrons at magnons in itinerant magnets is very important for the fields of spintronics and magnonics, and therefore an ab-initio treatment of these processes is highly desirable. The transition matrix elements for these scattering events are constructed in a second quantization formalism for crystal electron states which are represented by linear-muffin-tin-orbital basis functions. The exchange parameter appearing in these matrix elements is related to the exchange-correlation potential matrix of the spin-density functional theory. A comparison with the theory of electron-phonon scattering in magnets is made.

MA 14.10 Tue 11:45 H23

A comparison of magnetic and non-magnetic Compton profiles for locally dynamic correlated electrons of Fe, Ni and Cr. — •Liviu Chioncel[1], Diana Benea[2], Jan Minar[3], Hubert Ebert[3], Christoph Hugenschmidt[4,5], Hubert Ceeh[4], Michael Leitner[6], and Peter Boeni[4] — [1]Augsburg Center for Innovative Technologies, University of Augsburg, D-86135 Augsburg, Germany — [2]Faculty of Physics, Babes-Bolyai University, Ro-400084 Cluj-Napoca, Romania — [3]Chemistry Department, University Munich, D-81377 München, Germany — [4]Technische Universität München, Physik Department E21, D-85748 Garching, Germany — [5]FRM II, Technische Universität München, D-85747 Garching, Germany — [6]Technische Universität München, Physik Department E13, D-85748 Garching, Germany

The total and magnetically resolved Compton profiles are analyzed within the combined Density Functional and Dynamical Mean Field Theory (DMFT) for the transition metal elements Fe, Ni and Cr. A relative good agreement between the measured and computed Magnetic Compton profiles of Fe and Ni is obtained with the standard Local Density or the Generalized Gradient correction, while larger discrepancies are seen for the total Compton profile. Including many-body correlations captured by DMFT the computed Magnetic Compton profile is further improved, while no significant improvement is seen for the total Compton profile. We are lead to the conjecture that MCP encodes local correlations, while a correct theoretical description of the total CP may require the presence of non-local interactions.

MA 15: Spintronics and Magnetic Semiconductors (jointly with HL)

Time: Tuesday 9:30–12:00 Location: H3

MA 15.1 Tue 9:30 H3

Low versus high energy excitations in the Skyrmion lattice system Cu_2OSeO_3 — •Dirk Wulferding[1], Peter Lemmens[1], Vladimir Gnezdilov[2], Yurii Pashkevich[3], Christian Pfleiderer[4], and Helmuth Berger[5] — [1]IPKM, TU-BS, Braunschweig — [2]ILTPE, Kharkov, Ukraine — [3]DonFTI, Donetsk, Ukraine — [4]Physikdepartment, TU München — [5]EPFL, Lausanne, Switzerland

Cu_2OSeO_3, a ferromagnetic insulator with a skyrmion lattice phase previously known from intermetallics, shows low as well as high energy excitations that strongly depend on small applied magnetic fields. In particular, the low energy anomalies are discussed in relation to the Skyrmion lattice. Work supported by DFG, B-IGSM and NTH School for Contacts in Nanosystems.

MA 15.2 Tue 9:45 H3

Electron Dynamics in a Ferrocene-Based Mixed-Valence Compound — •Nicolas Yeche[1], Lucas Mäde[1], Alexander Hildebrandt[2], Ulrike Pfaff[2], Simon Liebing[3], Marco Günther[1], Heinrich Lang[2], Jens Kortus[3], and Hans-Henning Klauss[1] — [1]TU Dresden, Dresden, Germany — [2]TU Chemnitz, Chemnitz, Germany — [3]TU Freiberg, Freiberg, Germany

Mixed-valence compounds are metal-organic molecules in which the metal centres, a priori identical, are in different oxidation states. These compounds usually stabilize through a strong electron delocalization between the various metallic atoms. Thanks to Mössbauer spectroscopy measurements, we followed the charge dynamics in the monocationic form of 2,5-Diferrocenyl,1-Phenyl-1H-Pyrrole. There, two a priori symmetrical ferrocene moieties contain one Fe(III) and one Fe(II).

We present results obtained from the solid state as well as in dispersed molecules in a tetrahydrofurane glass. From the fluctuation of the electric field gradient (EFG) at the iron nuclei sites we follow the charge fluctuation rate from room temperature down to 4.2K. Results on the average EFG are then compared with DFT calculations.

MA 15.3 Tue 10:00 H3

Flux quantization in spintronic devices — •Wei Chen, Peter Horsch, and Dirk Manske — Max Planck Institute for Solid State Research, Stuttgart

We show that electric flux vector, defined as the cross product of electric field and trajectory, manifests quantization in various spintronic devices in the same sense as quantization of magnetic flux in a SQUID. This quantization is related to many fascinating phenomena such as field-adjustable spin Josephson effect, the current-voltage characteristics of spin-FET, and persistent spin current in a metallic ring. In the case where the quantization is purely due to Aharanov-Casher effect, the flux quantum is determined only by fundamental constants.

MA 15.4 Tue 10:15 H3

Three-magnon splitting process and efficiency of spin pumping in YIG/Pt bilayer — •Oleksandr Dzyapko[1], Vladislav Demidov[1], Hidekazu Kurebayashi[2], and Sergej Demokritov[1] — [1]Institute for Applied Physics, University of Münster, Münster, Germany — [2]Cavendish Laboratory, University of Cambridge, Cambridge, UK

Spin pumping is a process of generation of electron spin current from magnetic dynamics (spin-wave spin current). Recently, it has been shown that in YIG/Pt bilayers a process of three magnon splitting, influencing magnetic dynamics in the ferromagnet can enhance the efficiency of spin current generation in to adjacent metallic layer [1]. However, in the similar experiment performed by another group, the authors claim to observe the enhancement of a spin current in a YIG/Pt-system with a thin YIG-layer, for which the tree-magnon splitting is forbidden [2]. In order to clarify the role of the three magnon splitting process we performed a set of experiments in YIG/Pt bilayers with YIG-film of different thicknesses. The existing theory predicts that the frequency range in which the three magnon splitting process is allowed shrinks with decreasing film thickness. In agreement with the theory, the enhanced efficiency of spin current generation was observed at those frequencies, where the three magnon splitting processes is allowed, clearly demonstrating a close correlation between these two effects.

1.H. Kurebayashi, et al., Nature Mater. 10, 660 (2011).
2.V. Castel, et al., Phys. Rev. B 86, 134419 (2012).

MA 15.5 Tue 10:30 H3

Optimization of spin pumping in YIG/Pt structures — •Matthias Benjamin Jungfleisch, Viktor Lauer, Roland Neb, Andrii V. Chumak, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany

Spin pumping in yttrium iron garnet (YIG)/platinum (Pt) structures is an interface effect and, thus, it is of crucial importance to investigate the influence of surface processing of the ferromagnetic YIG layer before the Pt deposition.

Here, we present for the first time, systematic studies on the YIG/Pt interface, which improve the spin pumping efficiency. The spin currents generated by spin pumping in the Pt layer are detected by the inverse

spin Hall effect (ISHE). Three sets of YIG/Pt samples with different YIG thicknesses and constant Pt thickness of 10 nm were investigated. Spin pumping was driven by the ferromagnetic resonance excited by an external microwave signal. We measure the FMR spectra using a conventional microwave technique, as well as the ISHE induced voltage, allowing us to calculate the spin pumping efficiency defined as the ratio of the detected ISHE charge current to the absorbed microwave power. We succeeded in improving the spin pumping efficiency by a factor of more than 150.

Financial support by the Deutsche Forschungsgemeinschaft CH 1037/1-1 is gratefully acknowledged.

MA 15.6 Tue 10:45 H3

Physical, chemical and structural characterization of the antiferromagnetic semiconductor LiMnAs. — •Andreea Beleanu, Guido Kreiner, Walter Schnelle, Gerhard H. Fecher, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, Dresden, Germany.

The compound LiMnAs is a promising candidate for spintronic applications due to its antiferromagnetic and semiconducting behavior. Polycrystalline LiMnAs was obtained as single-phase material from stoichiometric amounts of high purity elements. The compound was characterized by powder x-ray diffraction, metallographic examinations, chemical and thermal analysis and by measurements of magnetic and transport properties. LiMnAs crystallizes in the tetragonal space group $P4/nmm$ with an antiferromagnetic order. It undergoes a phase transition to a cubic phase at 600°C. DC resistivity measurements indicate a semiconducting behavior. Using the Arrhenius plot two sections of activated conduction with a small band gap E_g of 0.21 eV indicating doped levels at low temperatures and a larger E_g of 0.57 eV at high temperatures were determined.

MA 15.7 Tue 11:00 H3

Creep/recovery and $1/f^\alpha$ noise signatures of resistively switching manganites — •Jon-Olaf Krisponeit, Christin Kalkert, Bernd Damascke, Vasily Moshnyaga, and Konrad Samwer — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Perovskite manganites show various interesting resistance effects, such as a metal-insulator transition driven by temperature as well as magnetic fields (colossal magnetoresistance). They also belong to a wide class of oxides which exhibit electrically induced resistive switching. Despite extensive efforts, the underlying mechanism of the switching effect, which possesses a high potential for applications, is still far from being understood.

We report the results on the dynamics of resistive switching on $La_{0.8}Ae_{0.2}MnO_3$ (Ae = Ca, Sr thin film samples. By means of conductive atomic force microscopy (C-AFM) we studied the time evolution of nanoscaled metallic domains. Creep/recovery features show up in pulse-train experiments and current map sequences. Moreover, the current $I(t)$ exhibits $1/f^\alpha$ noise signatures during the switching process. Such behavior is characteristic for various avalanche-type physical processes, like, for instance, the Barkhausen effect and martensitic transitions. Therefore, our results indicate the resistive switching effect to belong to this class of phenomena, and the dynamics to be governed by pinning and depinning of structural domain walls.

Financial support by DFG via SFB 602 and the Leibniz Program is acknowledged.

MA 15.8 Tue 11:15 H3

Magnetic control of channel conductance in Metal Semiconductor Field Effect Transistors with magnetic ZnO channel — •Tim Kaspar[1], Danilo Bürger[1,2], Ilona Skorupa[1], Artur Erbe[1], Daniel Grimm[2,3], Oliver G. Schmidt[2,3], Manfred Helm[1], and Heidemarie Schmidt[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [2]TU Chemnitz, Reichenhainer Str. 39, 09111 Chemnitz, Germany — [3]IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany

We focus on the development of ZnO based devices, e.g. Schottky diodes with a magnetic ZnO depletion region [1]. Our work is motivated by the observation of s-d exchange interaction in magnetic ZnO below 50 K. For ZnO:Co we have shown that the magnetoresistance depends on the magnetic ion concentration, the free electron concentration and temperature [2]. Here we focus on the control of conductance in Metal Semiconductor Field Effect Transistors (MESFETs)with diluted magnetic ZnO channels by applied external electrical and magnetic fields. Co-doped magnetic ZnO channel layers with a Co concentration of 5 at% have been deposited by pulsed laser deposition. Ag/Au gate and Ti/Au source and drain contacts have been structured by optical lithography. The characteristics of the MESFETs with magnetic channel in external perpendicular magnetic fields up to 1.8 T are presented.

[1] Qingyu Xu, H. S.et al., Jpn. J. Appl. Phys.49, 043002(2010)
[2] Qingyu Xu, H. S.et al., Phys. Rev. B.76, 134417(2007)

MA 15.9 Tue 11:30 H3

Tuning the ultrafast magnetic dynamics in Gd-Doped EuO — •A. Schroer[1], M. Matsubara[2], A. Schmehl[3], J. Mannhart[4], A. Melville[5], D. G. Schlom[5], M. Trujillo Martinez[1], M. Fiebig[2], and J. Kroha[1] — [1]Universität Bonn — [2]ETH Zürich — [3]Universität Augsburg — [4]MPI-FF Stuttgart — [5]Cornell University

EuO is a dense ferromagnetic semiconductor with a Curie temperature of T_C = 69 K. Upon Gd-doping, $Eu_{1-x}Gd_xO$ undergoes a simultaneous ferromagnetic and insulator-metal transition, with a resistivity drop of several orders of magnitude, making it an interesting material or spintronics applications. The magnetic coupling J_{eff} between the Eu 4f moments is mediated by a virtual magnetic exciton (Eu 4f-5d mixing), enhancing the wave function overlap of the magnetic Eu orbitals. We show by pump-probe experiments that pumping electrons resonantly into the Eu 5d conduction band in pure EuO leads to an ultrafast increase of the ferromagnetic coupling J_{eff}, and that this coupling can be tuned from a further increase to a decrease by Gd doping. For this pump-induced non-equilibrium situation we calculate the RKKY-like, conduction electron induced magnetic coupling. We find that the magnetic interaction is in general oscillatory and decays spatially with a power law, like the equilibrium RKKY interaction, but the power law exponent is changed. The tuning of the pump-induced change of J_{eff} by Gd-doping is explained by a subtle interplay of correlation-induced shift of spectral weight and of a pump-induced redistribution of the conduction electron occupation.

MA 15.10 Tue 11:45 H3

Magnetism in geometrically frustrated $HgCr_2Se_4$ — •Michael Wagner[1], Sarah Dunsiger[1], Vladimir Tsurkan[2], Alois Loidl[2], and Christian Pfleiderer[1] — [1]Physik Department E21, Technische Universität München, 85748 Garching, Germany — [2]Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

Geometrically frustrated spin systems on a pyroclore lattice are prone to competing antiferromagnetic and ferromagnetic interactions. Under hydrostatic pressure the relative strength of the various magnetic interactions may be changed driving phase transitions of the ground state. We studied the chromium spinel $HgCr_2Se_4$, a ferromagnetic semiconductor with $T_c \approx 106$ K. We have measured the magnetization under pressure with a bespoke Cu:Be piston cylinder cell. Our measurements were carried out on a single crystal prepared by chemical transport reaction. As a function of temperature the magnetization vanishes at the curie temperature T_c which decreases as a function of pressure consistent with literature [1]. Furthermore we find some indications of critical behaviour.

[1] V. Srivastava. Journal of Applied Physics, 40:3, 1969

MA 16: Poster I

Topological Insulators, Multiferroics, Spin Structures and Magnetic Phase Transitions, Spin Excitations and Spin Torque, Magnetic Nanoparticles and Clusters,Magnetic Materials (Heusler, Semiconductors, Half-Metals, Oxides, Shape Memory), Magnetic Imaging and Scattering Methods,Bio- and Molecular Magnetism

Time: Tuesday 10:30–13:30 Location: Poster D

MA 16.1 Tue 10:30 Poster D

Following Photo-Induced Strains in Multiferroic $BiFeO_3$ Using Ultrafast X-Ray Diffraction — •Daniel Schick[1], Marc Herzog[1], Haidan Wen[2], Peter Gaal[3], and Matias Bargheer[1] — [1]Institut für Physik & Astronomie, Universität Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany — [2]X-ray Science Division, Argonne National Laboratory, Argonne, Illinois 60439, USA — [3]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Wilhelm-Conrad-Röntgen Campus, BESSY II, Albert-Einstein-Str. 15, 12489 Berlin, Germany

$BiFeO_3$ had a deep impact in the field of multiferroics, since it is magnetic and ferroelectric at room temperature, opening a wide field of applications, e.g. for spintronics and memory devices which can be addressed magnetically and electrically. Furthermore, it is highly desirable to photo-control the polarization and magnetization in $BiFeO_3$ directly by ultrafast optical excitation. Here we use femtosecond laser pulses with a photon-energy of 3.1eV ($\lambda = 400$nm) to excite a 40nm $BiFeO_3$ thin film above its band gap of 2.8eV. Ultrafast X-Ray Diffraction (UXRD) at a laser-driven Plasma X-Ray Source (PXS) is applied to follow the subsequent lattice dynamics on a sub-picosecond timescale. We observe a fast evolution of the photo-induced strains in the excited $BiFeO_3$ within 10ps. We compare these UXRD results with broadband all-optical experiments to get a deeper understanding of the origin of these strains in $BiFeO_3$ induced by the interband excitation.

MA 16.2 Tue 10:30 Poster D

Magnetic and dielectric properties of doped magnetite - multiferroicity? — •Eugen Ruff[1], Florian Schrettle[1], Stephan Krohns[1], Peter Lunkenheimer[1], Victor A.M. Brabers[2], and Alois Loidl[1] — [1]Experimental Physics V, University of Augsburg, 86135 Augsburg, Germany — [2]Department of Physics, Eindhoven University of Technology, 5600 MB Eindhoven, Netherlands

We investigate pure and Al-doped magnetite (single-crystals) using magnetometry, specific heat measurements, and broadband dielectric spectroscopy to analyze the magnetic properties at the Verwey transition and to check for its ferroelectric properties. At low magnetic fields the magnetic moment of magnetite shows an interesting anomaly at the Verwey transition. One can speculate, that this is due to magnetic softening, which is verified by magnetization measurements around the Verwey temperature. For an Al-content $x < 0.3$ ($Fe_{3-x}Al_xO_4$) the anomaly shifts to lower temperatures with increasing x and for $x \geq 0.03$ it is suppressed. The results of dielectric spectroscopy and specific heat measurements confirm this behavior. At low temperatures, the dielectric properties of the low doped samples are consistent with relaxor ferroelectricity as evidenced by Schrettle et al. [PRB 83, 195109 (2011)] for the undoped material. We found the detected relaxorlike peak to be strongly influenced by doping. The analysis of the temperature dependent relaxation time reveals a freezing of polar dynamics, which becomes faster with higher doping level.

MA 16.3 Tue 10:30 Poster D

magnetic and topological properties of edge states in the multi-band superconductor Sr_2RuO_4 — •Yoshiki Imai[1], Katsunori Wakabayashi[2], and Manfred Sigrist[3] — [1]Department of Physics, Saitama University, Japan — [2]WPI-MANA, NIMS, Japan — [3]Theoretical Physics, ETH-Zurich, Switzerland

Motivated by spin-triplet superconductor Sr_2RuO_4, the magnetic and topological properties of the edge states are investigated by means of the ribbon-shaped model with three Fermi surfaces as electronlike, holelike and two-dimensional ones, which correspond to the α-β bands and γ band of Sr_2RuO_4 in the two-dimensional bulk system. While there exists a full quasiparticle excitation gap, the gapless edge states appear in the ribbon system, in which these edge states are topologically protected and produce the spin and charge currents. While spin current results from the spin-orbit interaction, the charge current appears even without the external magnetic field and originates from the time-reversal symmetry breaking in chiral p-wave superconducting condensate. The effect of the repulsive interaction gives rise to the spin-polarization near the edges due to the Stoner mechanism. The magnetization from the currents couples correlation-induced magnetism through the spin-orbit interaction, so that the orientation of both magnetization is uniquely determined. The net spontaneous magnetic field from the edge current is strongly reduced due to the compensation of magnetic fields induced by correlation effect. This obtained result may explain the negative result from the experimental searches for chiral edge currents.

MA 16.4 Tue 10:30 Poster D

***Ab initio* description of topological insulators** — •Christian Franz, Michael Czerner, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, Giessen, Germany

In this contribution we investigate 3D topological insulators (TI) using ab initio methods. These materials are insulating as bulk material but have a conducting surface state bridging the band gap, which is protected by time reversal symmetry. Prominent examples of 3D-TIs are BiSb alloys and Bi_2Se_3. In addition to being protected against (non-magnetic) impurities and other perturbations, the spin of these surface states is locked to their momentum. Therefore, backscattering is suppressed for this states, creating a two dimensional electron gas with high mobility. This inspired many proposed application.

We analyze the band structure of TIs. Since the spin-orbit interaction which creates a band inversion is crucial in TIs we will use a fully relativistic description. This is compared to a result without spin-orbit interaction to identify the band inversion. The appearance of the surface state is demonstrated using half-infinite boundary conditions. Alloys are described using the coherent potential approximation. This is the first step towards an *ab initio* description of transport in TIs.

MA 16.5 Tue 10:30 Poster D

A scanning tunneling spectroscopy investigation of the Bi_2Te_3 surface — •Thomas Bathon, Paolo Sessi, Lydia El-Kareh, and Matthias Bode — Physikalisches Institut, Experimentelle Physik II, Universität Würzburg,

We present a combined scanning tunneling microscopy (STM) and spectroscopy (STS) characterization of the structural and electronic properties of the topological insulator Bi_2Te_3. By interpreting the bias-dependent topographical evolution of defects we can show that they make samples n-doped. With the help of Fourier-transformed dI/dU maps we study scattering processes around defects and reveal that backscattering is forbidden for topological surface states. Based on bias-dependent measurements we determine the energy dispersion relation, the position of the Dirac point, and the carrier velocity. We also show that, by moving away from the Dirac point, the linear dispersion relation—which is typical for massless Dirac fermions—does not hold anymore. Instead, strong warping effects can be detected.

MA 16.6 Tue 10:30 Poster D

Influence of substrate imposed strain on epitaxially grown $BiFeO_3$ thin films investigated by Raman spectroscopy — •Andreas Talkenberger[1], Cameliu Himcinschi[1], Florian Johann[2], Ionela Vrejoiu[2], and Jens Kortus[1] — [1]TU Freiberg, Inst. of Theor. Physics, Leipziger Str. 23, D-09596 Freiberg — [2]Max Planck Inst. of Microstr. Physics, Weinberg 2, D-06120 Halle

$BiFeO_3$ (BFO) is an interesting candidate for multiferroic applications. Therefore a deep understanding of the material properties and the fabrication of high quality epitaxial thin films is necessary. In this work we investigated epitaxially grown BFO thin films fabricated by pulsed laser deposition on $SmScO_3$ (110), $GdScO_3$ (110) and $DyScO_3$ (110) substrates by means of Raman spectroscopy. The BFO films on $DyScO_3$ were synthesized with 71° and 109° stripe domain patterns[1,2]. The Raman spectra were recorded using the 532 nm emission line of a frequency doubled Nd:YAG laser as well as the 442 nm emission line of a He-Cd laser. The wave number shift of the phonon modes at 171 and 220 cm^{-1} correlates to the epitaxial strains in the BFO films grown on the different substrates. Further, we found an anomalous behaviour of the phonon mode at 140 cm^{-1}. While the modes at 171 and 220 cm^{-1} are redshifted with increasing tensile strain, the mode at 140 cm^{-1} is blueshifted. A similar anomalous effect was observed previously in $BiCrO_3$ films for the phonon mode at 180 cm^{-1}. This work is supported by the German Research Foundation DFG HI 1534/1-1 and SFB762. [1] F.Johann, Phys. Rev. B 84, 094105 (2011), [2] F.Johann, Phys. Status Solidi B 249, 2278 (2012)

MA 16.7 Tue 10:30 Poster D

Localized magnetoelectric effect in $BaTiO_3$/Hexaferrite composite ceramics — •Harsh Trivedi[1], Vladimir Shvartsman[1], Doru Lupascu[1], Rob Pullar[2], and Andrei Kholkin[2] — [1]Institute für Materialwissenschaft, Universität Duisburg-Essen, Essen Germany — [2]CICECO, University of Aveiro, Aveiro, Portugal

Due to its novel technological implications, the magnetoelectric(ME) effect has led to a bright prospectus for materials that show a direct or indirect coupling between the magnetic and electric order parameters. Owing to scarcity of intrinsic multiferroics, the strain mediated com-

posite systems are a promising approach towards realizing an increased magnetoelectric coupling in bulk materials. The present state of the art in these materials demand concerted efforts toward a better understanding of microscopic mechanisms in the coupling phenomena. Since bulk ME measurements suffer inherent drawbacks concerned with electrical poling, in this work we have studied localized ME effect using scanning probe microscopy(SPM) techniques like Magnetic Force Microscopy(MFM) and Piezoresponse Force Microscopy(PFM) of bulk ME composite ceramics with a homogeneous distribution of piezoelectric($BaTiO_3$) and ferrite($BaFe_{12}O_{19}$/$SrFe_{12}O_{19}$) phases. MFM shows a clear restructuring of juxtaposed magnetic domains indicating motion of the domain walls under the effect of applied electric field. Also we observed the effect of magnetic field on the localized hysteresis behavior of constituent $BaTiO_3$ phase. The observed ME coupling is attributed to strain induced changes taking place

MA 16.8 Tue 10:30 Poster D

Electrically induced magnetic transition at the LSMO/BTO interface — •Markus Schmitz[1], Alexander Weber[1], Daniel Schumacher[2], Paul Zakalek[1], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS und Peter Grünberg Institut PGI, Forschungszentrum Jülich GmbH, Germany — [2]Deutsches Elektronen Synchrotron DESY, Hamburg, Germany

The magnetoelectric coupling is one of the most fascinating and active research areas today. The control of the magnetism due to an applied electric field may lead to new device concepts. First principles calculations of $La_{(1-x)}Sr_xMnO_3$/$BaTiO_3$(001) interfaces show magnetic reconstructions due to the change of the polarization of BTO by applying an external electric field [1]. The different electron densities influence the equilibrium between super- and double-exchange favoring a ferromagnetic or an antiferromagnetic order at the interface for the two different orientations of the polarization. Here we report on LSMO/BTO, grown with an Oxide Molecular Beam Epitaxy system. The epitaxial layer-by-layer growth was confirmed by in-situ RHEED analysis and the crystalloine quality of the surface was investigated by LEED and Atomic Force Microscopy. The structural characterization was carried out by X-ray reflectometry and X-ray diffraction. The macroscopic magnetic properties were determined by MOKE and SQUID magnetometry.

[1] Burton, J. D. and Tsymbal, E. Y. (2009) Prediction of electrically induced magnetic re- construction at the manganite/ferroelectric interface. Phys. Rev. B , 80, 174406.

MA 16.9 Tue 10:30 Poster D

Mechanisms of Multiferroicity of $GdMnO_3$ explored by Resonant Soft X-Ray Scattering in High Magnetic Fields — •Enrico Schierle[1], Victor Soltwisch[1], Christoph Trabant[1,2], Alex Frano[1,3], Sven Landsgesell[1], Fabiano Yokaichiya[1,4], Detlef Schmitz[1], Andrej Maljuk[1,5], Christian Schüssler-Langeheine[1], Ralf Feyerherm[1], Dimitri Argyriou[1,6], and Eugen Weschke[1] — [1]Helmholtz-Zentrum Berlin, Germany — [2]Universität zu Köln, Germany — [3]MPI-FKF Stuttgart, Germany — [4]Laboratrio Nacional de Luz Sincrotron, Campinas-SP, Brasil — [5]IFW, Dresden, Germany — [6]ESS, Lund, Sweden

Several orthorhombic $REMnO_3$ oxides show strongly coupled ferroelectric (FE) and magnetic order, with FE polarization induced by Mn-spin cycloids[1,2]. There is now growing evidence for a decisive role of ordering of the RE-4f moments as well[3-5]. $GdMnO_3$ seems to be the prime candidate for multiferroicity connected with magnetic RE order[4]. We employed Resonant Soft X-Ray Scattering to explore the magnetic Gd-4f and Mn-3d spin order and its coupling to ferroelectricity. While the prominent features can be already observed in the Zero-field FE phase, detailed knowledge could be derived by studying the magnetic field stabilized FE phase using the High-Field-Diffractometer operated at the UE46-PGM-1 beam line at BESSY II.
[1] Kimura et al., Nature 426, 55-58 (2003) [2] Kenzelmann et al., PRL 95, 087206 (2005) [3] Schierle et al., PRL 105, 167207 (2010) [4] Feyerherm et al., Journal of Physics: Conference Series 200, 012032 (2010) [5] Walker et al., Science 333, 1273 (2011)

MA 16.10 Tue 10:30 Poster D

Nonlinear optical probing in $(Ba,Sr)TiO_3$/$La_{0.7}Sr_{0.3}MnO_3$ multilayers — •Johannes Aprojanz[1,2], Arseni Buryakov[2], Elena Mishina[2], Markus Michelmann[1], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]Moscow State Institute of Radioengineering, Electronics and Automation, Prosp. Vernadskogo 78, 119454 Moscow, Russia

Ferroelectric oxides stand out due to their excellent nonlinear optical properties and strong electro-optic effect, which offer promising applications as electro-optical modulators. Second harmonic generation (SHG) as a nonlinear optical probe is a powerful tool for studying ferroelectric switching, since it gives direct insight into the domain state in the material. In this work, we report on SHG measurements on $Ba_xSr_{1-x}TiO_3$/$La_{0.7}Sr_{0.3}MnO_3$ (BSTO/LSMO), $x = 0.15-0.5$, multilayers grown on $SrTiO_3$ substrates by means of metalorganic aerosol deposition (MAD). The voltage characteristics of SHG-signal prove ferroelectric hysteretic behavior at room temperature with switching fields in the range of 100 kV/cm. A detailed study of ferroelectric properties will be given as a function of magnetic field, $B = 0 - 1$ T.
This work was supported by IFOX of the European Community's 7th Framework Programme.

MA 16.11 Tue 10:30 Poster D

Anisotropy study of the magnetoelectric properties of $LiFeSi_2O_6$ — •Matthias Ackermann[1], Petra Becker[1], Ladislav Bohatý[1], and Thomas Lorenz[2] — [1]Institut für Kristallographie, Universität zu Köln — [2]II. Physikalisches Institut, Universität Köln

$LiFeSi_2O_6$ belongs to the class of pyroxenes with the general formula AMT_2O_6 (A=mono- or divalent metal, M=di- or trivalent metal, T=tetra- or trivalent metal). The members of this class are well known for their multiferroic/linear magnetoelectric properties. [1] The structure of $LiFeSi_2O_6$ consists of one-dimensional zig-zag chains of edge-sharing [FeO_6] octahedra running along the crystallographic c-axis. Within the (110) and ($\bar{1}$10) planes these chains are connected by chains of [SiO_4] tetrahedra. At 230 K the compound undergoes a structural phase transition with a change in space group symmetry from $C2/c$ to $P2_1/c$. [3] Below the magnetic ordering temperature $T_C \sim 18$ K $LiFeSi_2O_6$ belongs to the magnetic space group $P2_1/c'$ [2] and shows the linear magnetoelectric effect. In this contribution we present a detailed investigation of the linear magnetoelectric properties and their anisotropy of this compound.
This work was supported by the DFG through SFB 608.
[1] S. Jodlauk et al. J. Phys.: Condens. Matter **19**, 432201 (2007)
[2] G. J. Redhammer et al. Phys Chem Min. **28**, 337 (2001)
[3] M. Behruzi et al. Acta Crystallogr. A **40** (Suppl.), C-247 (1984)

MA 16.12 Tue 10:30 Poster D

Coupling effects at the interface of nanostructured $BiFeO_3$/$La_{0.7}Sr_{0.3}MnO_3$ und epitaxial strain — •Christian Mix[1,2], Simone Finizio[1,2], Robert Reeve[1], Pascal Krauscheid[1], Frank Demuth[1], Christian Engel[1], Mathias Kläui[1], and Gerhard Jakob[1] — [1]Institute of Physics, Universität Mainz — [2]Graduate school of excellence MAINZ, Mainz

$BiFeO_3$ (BFO) is one of the few room temperature multiferroics, possessing antiferromagnetic and ferroelectric order [1, 2]. Imaging the domain structure with respect to the interface of artificial multiferroics is of increasing interest to understand the nature of magnetoelectric and exchange coupling at the interface [3].

Here, we report on heteroepitaxial growth of $BiFeO_3$ thin films under different levels of epitaxial strain and buffered by LSMO of varying thickness. Piezo force microscopy (PFM) and reciprocal space maps are utilized to investigate the influence of epitaxial strain on crystal structure and ferroelectric domain structure. In addition, scanning electron microscopy with spin polarization analysis (SEMPA) and x-ray magnetic circular and linear diachroism (XMCD, XMLD) photo emission microscopy (PEEM) are used to investigate the ferromagnetic and antiferromagnetic domain structure in BFO/LSMO bilayer structures.
Financial support by Stiftung Innovation für Rheinland-Pfalz (Project 961-386261/944) is gratefully acknowledged.

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MA 16.13 Tue 10:30 Poster D

Understanding the phase sequence of Fe-Pd alloys from first principles — •Markus Ernst Gruner[1], Sandra Kauffmann-Weiss[2], Sven Hamann[3], Peter Entel[1], Sebastian Fähler[2], and Alfred Ludwig[3] — [1]Faculty of Physics and CeNIDE, University of Duisburg-Essen, 47048 Duisburg — [2]IFW Dresden, P.O. Box 270116, 01171 Dresden — [3]Institute of Materials, Ruhr-Universität Bochum, 44801 Bochum

Just as the prototypical Ni-Mn-Ga Heusler system also the disordered

face centered $Fe_{70}Pd_{30}$ alloy shows large magnetic field induced strains in a slightly tetragonal fct martensite. Recent experiments achieved epitaxial growth of $Fe_{70}Pd_{30}$ thin films with $c/a = 1.09$, thus extending the classical Bain path beyond the fcc end [PRL 107, 206105 (2011)]. The combination of XRD spectroscopy and DFT modelling reveals that this process is related to an alternative relaxation mechanism, which leads to a nanotwinned pattern constructed from fct building blocks. The extremely low formation energy of the fct twins results in a finely twinned superstructure in the simulation cell along [110], which corresponds to the experimentally observed soft transversal acoustic phonon in this direction. This is also a central feature of the Ni-Mn-Ga magnetic shape-memory Heusler compound and allows us to interpret the fct phase analogously as a metastable adaptive martensite, where the increasing twin defect energy at larger distortions prevents the relaxation to the bcc ground state. The close interrelation between electronic and structural properties can be exploited to tailor the phase sequence in magnetic shape-memory ternary alloys.

MA 16.14 Tue 10:30 Poster D

High-field magnetization and magnetoelasticity of single crystalline $HoFe_5Al_7$ — •S. Yasin[1], A.V. Andreev[2], D. Gorbunov[2], Y. Skourski[1], S. Zherlitsyn[1], and J. Wosnitza[1] — [1]Dresden High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany — [2]Institute of Physics ASCR, Na Slovance 2, 18221 Prague 8, The Czech Republic

Magnetization and ultrasound measurements have been performed in pulsed magnetic fields up to 60 T on a ferrimagnetic $HoFe_5Al_7$ single crystal (Curie temperature T_C = 213 K, compensation point T_{comp} = 65 K) with tetragonal crystal structure of $ThMn_{12}$ type. The compound poses an "easy-plane" magnetic anisotropy with the easy magnetization direction along the [110] axis and spontaneous magnetic moment $M_s = 2\ \mu_B$/f.u. at $T = 2$ K. For the magnetic field applied along this direction two field-induced magnetic transitions of first-order are observed. The presence of both transitions is accompanied by sharp anomalies in the acoustic properties. The temperature dependences of the critical fields as well as the shape of the acoustic anomalies suggest a different nature of the above magnetic transitions. The magnetoelastic study has been supplemented with magnetization measurements under hydrostatic pressure. T_C decreases with a rate dT_C/dp = -10 K/GPa, whereas T_{comp} increases with dT_{comp}/dp = 3.5 K/GPa. We discuss our results in relation to the exchange interactions of the Ho-Fe sublatices. *Part of this work was supported by EuroMagNET under the EU contract No. 228043.

MA 16.15 Tue 10:30 Poster D

First-principles study of the magnetic phases of bcc and fcc Fe — •David Reith[1], Pedro Bedolla[2], Raimund Podloucky[1], Peter Mohn[2], Tobias C. Kerscher[3], Sascha B. Maisel[3], and Stefan Müller[3] — [1]Universität Wien — [2]TU Wien — [3]TU Hamburg-Harburg

The cluster expansion (CE) technique in combination with Monte-Carlo simulations [1] is applied for deriving temperature and magnetic field dependent stabilities of the magnetic phases of bcc and fcc Fe. The input structures as calculated by VASP [2,3] provide the total energies of the spin configurations as needed for the CE. In addition to the standard spin-polarized configurations utilized for fcc Fe, the magnetic structures for bcc Fe also includes non-collinear orientations in order to model spin fluctuations. The magnetic field for the MC simulation is implemented in terms of a chemical potential. (Supported by FWF.)

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MA 16.16 Tue 10:30 Poster D

The Strong Disorder Renormalisation Group and Tensor Network Methods — •Andrew Goldsborough and Rudolf Römer — Department of Physics and Centre for Scientific Computing, The University of Warwick, Coventry, United Kingdom

We have developed a tensor network method of performing the numerical strong disorder renormalisation group (SDRG) approach [1] on the random 1D spin-1/2 Heisenberg model. We use matrix product operators (MPOs) as a means of describing the Hamiltonian. The coarse-graining is achieved by concentrating on the interaction with the largest energy gap and calculating the lowest eigenvectors of the two-site hamiltonian. This unitary operator can then be contracted with the two-site MPO to create a new one site MPO. The idea can be interpreted as a multi-level coarse-graining of the Hamiltonian or as a multi-level tensor network state with the form of a binary tree tensor network (TTN). This realisation enables us to use the methods of TTNs and MERAs (multi-scale entanglement renormalisation ansatz) to gain more control over the system. We will show first results and compare the performance all methods.

[1] T. Hikihara, A. Furusaki, and M. Sigrist, Phys. Rev. B 60,12116 (1999)

MA 16.17 Tue 10:30 Poster D

Magnetic Order and Magnon Dispersion Relation in Ultrathin Fe and FePd Alloy Films Grown on Pd(100) — •Huajun Qin, Tzu-Hung Chuang, Yu Zhang, Khalil Zakeri Lori, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

Ultrathin Fe films with thicknesses of one and two atomic layers were grown on Pd(100) substrate at room temperature. Spin-polarized electron energy loss spectroscopy (SPEELS) has been utilized to measure the magnon dispersion relation. The results are compared to the ones of a chemically disordered FePd alloy film, with a thickness of two atomic layers, prepared by mild annealing of an Fe monolayer on Pd(100) surface at the temperature of 400 K [1]. All SPEELS measurements are performed at T=13 K. It is found that the magnon energies in the 2 ML FePd alloy film are considerably higher than the ones in the Fe monolayer, but are comparable to the ones in the 2 ML Fe film. This observation may be attributed to the enhanced Pd magnetic moment in the FePd alloy film and the role of interlayer exchange coupling. Our dynamic measurements predict that the alloy films shall have a higher Curie temperature than the Fe monolayer, in good agreement with our static measurements obtained by means of magneto-optical Kerr effect.

[1] H.L. Meyerheim, R. Popescu, and J. Kirschner, Phys. Rev. B **73**, 245432 (2006).

MA 16.18 Tue 10:30 Poster D

Depinning of magnetic domain walls using pure spin currents — •Nils Motzko[1], Björn Burkhardt[1], Piotr Laczkowski[2], Laurent Vila[2], and Mathias Kläui[1] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz — [2]Laboratoire Nanostructure et Magnetisme, CEA/INAC, 38054, Grenoble, France

The controlled motion of magnetic domain walls (DWs) is a vital component of various spintronic devices and memory applications, however, conventional methods of DW manipulation via fields or charge currents suffer from limitations due to their scalability or due to Joule heating. An alternative approach is to employ pure spin currents, for example in non-local spin valve (NLSV) configurations. In our measurements the NLSV consists of two permalloy halfrings which are connected via a non-magnetic copper conduit, a geometry which permits the precise positioning of DWs. Here, we analyze the influence of a pulsed spin current on the depinning field of a DW and we observe pure spin current induced depinning without any external field at a charge current density of $0.5*10^{12}$ A/m^2 and a corresponding spin current density of $6.7*10^9$ A/m^2. The calculated efficiency ($1.1*10^{-12}$ T/(A/m^2)) is more than 100 times higher than for current induced DW motion (CIDM) (M. Laufenberg et. al., Phys. Rev. Lett. 97, 046602 (2006)). This is attributed to the fact that in our measurements the pure spin current acts as a torque completely perpendicularly to the DW magnetization due to the NLSV design maximizing the acting torque.

MA 16.19 Tue 10:30 Poster D

Control of magnetization dynamics by pure spin currents — •Henning Ulrichs[1], Vladislav Demidov[1], Sergej Demokritov[1], and Sergei Urazhdin[2] — [1]University of Muenster, Corrensstrasse 2-4, 48149 Muenster, Germany — [2]Emory University, Atlanta, GA 30322, USA

Recent experiments have shown that pure spin currents can be used to realize efficient control of magnetization dynamics, opening new possibilities for implementation of high-frequency spintronic devices. Here, we review our experimental studies [1-4] on this subject using micro-focus Brillouin light scattering spectroscopy.

We demonstrate that pure spin currents can be utilized for wide-range control of the effective magnetic damping in micrometer-sized structures. In particular, we achieved a reduction of the damping coefficient significantly below values typical for the used magnetic material. This effect can be utilized for stimulation and electric control of nonlinear dynamic phenomena such as parametric spin-wave instabil-

ity. In addition, we study the effect of pure spin currents on thermal magnetic fluctuations and show that they can be controllably enhanced or suppressed. Finally, we demonstrate excitation of coherent single-mode auto-oscillations in devices where the local injection of pure spin currents results in a complete compensation of damping.

1. Phys. Rev. Lett. 107, 107204 (2011)
2. Appl. Phys. Lett. 99, 172501 (2011)
3. Phys. Rev. B 86, 134420 (2012)
4. Nature Materials 11, 1028 (2012)

MA 16.20 Tue 10:30 Poster D

Spin-transfer torque in Fe/MgO/Fe-MTJs with perpendicular magnetic anisotropy — •Jia Zhang, Michael Crezner, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, Giessen, Germany

Recently, it was shown that MgO based magnetic tunnel junctions (MTJs) with ultrathin CoFe magnetic electrodes can have perpendicular magnetic anisotropy (PMA) and a low current for current driven switching[1]. In this work, the perpendicular anisotropy and spin-transfer torque in Fe/MgO/Fe-MTJs with ultrathin magnetic Fe layers in the presence of spin-orbital coupling are investigated by full relativistic Korringa-Kohn-Rostoker (KKR) first-principles calculations[2]. First, the critical thickness of Fe with perpendicular anisotropy is determined by calculating the magnetic crystal anisotropy and the shape anisotropy. Second, the bias voltage and angular dependence of spin-transfer torques is calculated. It is found that spin-orbital coupling have three significant effects on the spin-transfer torque: (1) The PMA contributes a new out-plane pseudo-torque in addition to the interlayer exchange coupling torque. (2) The spin-orbital coupling greatly change the magnitude of the spin-transfer torque. (3) The tunneling anisotropy leads to a strong angular dependence of spin-transfer torque.

[1] S. Ikeda et al. Nature Mater. 9, 721(2010).

[2] C. Heiliger et al., Phys. Rev. Lett. 100, 186805 (2008) ; J. Appl. Phys. 103, 07A709 (2008)

MA 16.21 Tue 10:30 Poster D

A theoretical analysis of the spin dynamics of magnetic adatoms traced by pump-probe scanning tunneling spectroscopy — •Michael Schüler, Yaroslav Pavlyukh, and Jamal Berakdar — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Heinrich-Damerow-Straße 4, 06120 Halle

The inelastic tunneling spectroscopy (IETS) provides a very suitable tool for the detailed analysis of the magnetic properties of adatoms and molecules. Furthermore, the inelastic scanning tunneling microscopy (STM) using a spin-polarized tip also allows for manipulating the spin configuration and for tracing the nanosecond spin dynamics of the magnetic adsorbates in a pump-probe manner. Based on a non-perbutative model, we theoretically investigate the excitation mechanism of the sample spin, its dependence on the anisotropic environmentand demonstrate how the relaxation dynamics can be monitored with the help of the tunnelling current. The predictions of a simple analytical model support our numerical findings and reveal the underlying physics. We also compare our results to recent experiments.

MA 16.22 Tue 10:30 Poster D

Current-induced spinwave doppler shift evidenced by time-resolved kerr microscopy — Jean-Yves Chauleau, Hans Bauer, •Helmut Koerner, Mirkow Ribow, Georg Woltersdorf, and Christian Back — Physics Departement, Universität Regensburg, universitätsstrasse 31, 93040 Regensburg, Germany

Action of spin-polarized electric currents on magnetic textures is now well established both from experimental and theoretical viewpoints. These effects are known as spin-transfer torques (STT). In the case of continuous magnetic distributions, current-induced domain wall (DW) dynamics is a recurrent system of investigation. However, DWs are fairly complicated magnetic structures whose dynamics is consequence of a subtle combination of damping, spin-drift velocity and non-adiabatic parameter. An alternative to domain walls dynamics has been reported by Vlaminck and Bailleul. The current-induced shift of spinwave resonances (spinwave Doppler shift) has been experimentally evidenced using an inductive approach.

In this study, we demonstrate the ability of time-resolved scanning Kerr microscopy (TRMOKE) to investigate the spin-transfer torque effects on propagating spin waves in Permalloy stripes. This approach allows not only the measurement of the full waves spectrum but also a direct imaging of the different modes present in the stripe. Wavevector, damping length and group velocity are directly measured experimentally. This is of utmost importance in order to accurately obtain the spin drift velocity, essential root of any evaluation and study of the non-adiabatic parameter.

MA 16.23 Tue 10:30 Poster D

All-electrical spin-wave spectroscopy on skyrmions in MnSi — •Ioannis Stasinopoulos[1], Thomas Schwarze[1], Andreas Bauer[2], Helmuth Berger[3], Johannes Waizner[4], Markus Garst[4], Christian Pfleiderer[2], Achim Rosch[4], and Dirk Grundler[1,5] — [1]Physik-Department E10, TU München, Garching, Germany — [2]Physik-Department, FG Magnetische Materialien, TU München, Garching, Germany — [3]EPFL, Institut de physique de la matiere complexe, Lausanne, Switzerland — [4]Institute for Theoretical Physics, Univ. Köln, Köln, Germany — [5]STI, EPFL, Lausanne, Switzerland

Skyrmions are topologically stable spin textures with the spins pointing in all directions wrapping up a sphere. The resulting core spins point in opposite direction compared to the outside ones. The recently discovered skyrmion phase (so-called A phase) is formed in a specific magnetic field-temperature (H-T) region of chiral helimagnets, such as MnSi, where skyrmions crystallize at about $T = 28\,\mathrm{K}$ and $\mu_0 H = 200\,\mathrm{mT}$ in a hexagonal lattice with a typical lattice constant of 18 nm. Our group uses an all-electrical microwave spectroscopy setup based on a vector analyzer and lithographically fabricated coplanar waveguides to excite and simultaneously probe the skyrmion states in MnSi. An out-of plane static magnetic field in combination with a He flow cryostat is used to define the skyrmion phase conditions. The observed resonances lie in the low GHz regime. Financial support by the DFG via TRR80 and NIM is acknowledged.

MA 16.24 Tue 10:30 Poster D

Magnetic and electric excitations of helices and Skyrmions in chiral magnets — •Johannes Waizner[1], Markus Garst[1], Achim Rosch[1], Ioannis Stasinopoulos[2], Thomas Schwarze[2], Andreas Bauer[3], Helmuth Berger[4], Christian Pfleiderer[3], and Dirk Grundler[2,5] — [1]Institute for Theoretical Physics, Univ. Köln, Köln, Germany — [2]Physik Department, E10, TU München, Garching, Germany — [3]Physik Department, FG Magnetische Materialien, TU München, Garching, Germany — [4]EPFL, Institut de physique de la matiere complexe, Lausanne, Swizerland — [5]STI, EPFL, Lausanne, Swizerland

An oscillating magnetic field induces precession in a ferromagnet resulting in a ferromagnetic resonance (FMR) that is described by the Kittel formula for a homogeneous magnetisation. We extend the theory of FMR to the case of chiral magnets, i.e., ferromagnets with a Dzyaloshinkii-Moriya interaction, taking into account the effect of demagnetisation fields. In the so-called conical phase, we find two magnetic modes whose weights depend on the polarisation of the driving magnetic field. In the Skyrmion lattice phase, several magnetic modes exist; we find that the mode with the largest weight has a smaller resonance frequency than the ones of the conical phase. As the Skyrmions carry polarisation in insulating chiral magnets, the modes can also be excited electrically. We compare our findings to recent experimental results.

MA 16.25 Tue 10:30 Poster D

Ac spin Hall effect in FMR spin pumping — •Dahai Wei, Martin Obstbaum, Markus Härtinger, Georg Woltersdorf, and Christian Back — Institut für Experimentelle und Angewandte Physik, Universität Regensburg,Regensburg, Germany

The spin Hall effect (SHE), which converts charge current into or from a spin current, has been intensively studied in order to understand its basic mechanism. Furthermore, different materials are investigated in the search for larger spin Hall angles needed for more efficient spin-charge conversions on the basis of dc spin and charge currents. In addition to searching for materials with larger SH angles, ac spin currents, which can be two orders of magnitude larger than the dc ones in spin pumping, may be very promising [1].

We studied both the ac and the dc SHE of Pt/Py bilayers by the ferromagnetic resonance (FMR) based spin pumping technique. The spin currents pumped into the Pt layer have both dc, and a much larger ac component which has not been measured up to now. The ac voltages generated by the ac spin Hall effect was directly picked up at the same frequency of the spin pumping.

[1]Hujun Jiao & Gerrit E. W. Bauer, AC Voltage Generation by Spin Pumping and Inverse Spin Hall Effect. arXiv:1210.0724.

MA 16.26 Tue 10:30 Poster D

Current-induced domain wall motion at low current densities in La0.7Sr0.3MnO3 nanostructures imaged with high resolution x-ray magnetic microscopy — S. Finizio[1], M. Foerster[1], C. A. F. Vaz[1,2], F. Büttner[1,2,5], M. Mawass[1], •R. Lo Conte[1], T. Miyawaki[3], A. Bisig[2], L. Méchin[4], F. Nolting[6], and M. Kläui[1] — [1]JGU, Mainz, Germany — [2]SwissFEL, PSI, Villigen PSI, Switzerland — [3]University of Nagoya, Nagoya, Japan — [4]GREYC, UMR 6072, CNRS-ENSICAEN-UCBN, Caen Cedex, France — [5]TU Berlin, Berlin, Germany — [6]SLS, PSI, Villigen PSI, Switzerland

The effect of current pulses on the magnetization of nanometric La0.7Sr0.3MnO3 (LSMO)-half-rings has been investigated by high resolution x-ray magnetic microscopy. The potential high spin polarization and low room temperature saturation magnetization of LSMO make it a promising candidate for spin-torque-based technology applications. Here we investigate Current-Induced Domain Wall Motion (CIDWM) in LSMO nanostructures at low current densities (1-5x10 GA/m2). Their magnetic configuration was imaged by X-ray Magnetic Circular Dichroism - Photoemission Electron Microscopy (XMCD-PEEM). We observe mainly an initial single vortex wall and DW transformations, annihilation and nucleation after current injection due to the low Curie temperature (Tc ~ 340K) of our nanostructures. Low velocity (~0.5mm/s)DW displacements have been observed and interesting information on the energetics of the DW configurations has been obtained. While low current densities allow to move walls, the low Tc of LSMO limits the application for a CIDWM-based technology.

MA 16.27 Tue 10:30 Poster D

3D soft x-ray imaging of magnetite coated microballoons for theranostic applications — •Andreas Späth[1], Hanno Dietrich[1], Birgit Graf-Zeiler[1], Gaio Paradossi[2], and Rainer H. Fink[1] — [1]Friedrich-Alexander Universität Erlangen-Nürnberg, Physical Chemistry II and ICMM, Erlangen, Germany — [2]Università di Roma Tor Vergata, Dipartimento di Scienze e Tecnologie Chimiche, Rome, Italy

Poly(vinylalcohol) stabilized microballoons (diameter 4 - 10 microns) are promising hybrid systems for various applications in theranostics. Their surface can easily be functionalized chemically, and they can be filled with a large variety of therapeutic gases, thus providing very good contrast agents in ultrasound imaging. By embedding superparamagnetic iron oxide nanoparticles (SPIONs) into the polymer shell magnetic field guidance and even a magnetothermally triggered drug release from these micro containers is possible. This could be a highly valuable progress in selective destruction of tumor cells with highly active pharmazeuticals.

Within this contribution we will clarify the shell morphology and SPION distribution in various batches of magnetically functionalized PVA microballoons by transmission soft x-ray microspectroscopy (TXM) and TEM and extend these investigations to third dimension by reconstructions of TXM focal series and x-ray holography. X-ray magnetic dicroism (XMCD) and SQUID measurements were applied for a basic magnetic characterization of the particles.

MA 16.28 Tue 10:30 Poster D

Measurement of magnetic moment distribution of ferrofluids with single nanoparticle resolution using atomic force microscopy — •Stephan Block[1] and Christiane A. Helm[2] — [1]ZIK HIKE, Fleischmannstr. 42 - 44, D-17475 Greifswald, Germany — [2]Institut für Physik, Ernst-Moritz-Arndt Universität, Felix-Hausdorff-Str. 6, D-17487 Greifswald, Germany

An atomic force microscopy (AFM) method is presented, which allows the simultaneous measurement of magnetic and geometric properties of nm-sized objects (nanoparticles, e.g. colloids or clusters). An oscillating magnetic field is applied to the sample and the surface magnetization is probed using a magnetic AFM-tip. Spatial changes of the magnetic flux density affect the vibration amplitude of the tip and thus, (dynamic) magnetic properties of the surface can be determined with a lateral resolution of few nanometers. The principles of the experimental setup and the data analysis are outlined. It is shown that the resolution is sufficiently high to resolve magnetic moments of single superparamagnetic maghemite nanoparticles (diameter > 4 nm). The approach is applied to determine the distribution of magnetic moments in different ferrofluids on a single particle level.

MA 16.29 Tue 10:30 Poster D

Granular GMR effects in systems with organic matrix — •Judith Meyer, Markus Schäfers, Thomas Rempel, and Andreas Hütten — Bielefeld University, Universitätsstr.25, 33615 Bielefeld

The giant magnetoresistance effect (GMR effect) was found in magnetic multilayer systems [1,2] and was later also reported within granular systems by several research groups who had embedded magnetic particles in a metallic matrix [3,4]. In contrast to previous granular layered systems, we have incorporated Co nanoparticles in a conductive nonmagnetic biogel. Transport measurements carried out using a 4-point-probe measurement at room temperature revealed GMR effects of more than 60 percent. AC transport measurements were found to improve the long-term stability of the effect amplitude. Regarding future applications, the possibility of printing gel will allow for the development of granular gel-GMR sensors more rapid and less expensive in fabrication compared to conventional devices. The large effect amplitudes will ensure high sensor sensitivity and the mechanical flexibility of the matrix might additionally open up new fields of application.

MA 16.30 Tue 10:30 Poster D

Individual and collective ferromagnetic resonance of 43 nm Fe/Fe_xO_y core/shell-nanocubes — •Alexandra Terwey, Ralf Meckenstock, Detelf Spoddig, Christian Schöppner, Marina Spasova, and Michael Farle — AG Farle, Experimentalphysik, Universität Duisburg Essen, Germany

Here we determine the magnetization, anisotropy and linewidth of 43 nm Iron/Ironoxide core/shell nanocubes, from a statistical distribution in solution over small agglomerates to single particles on a substrate. The nanocubes, surrounded by an organic matrix of ligands were produced according to a modified recipe of Kim et al. [1]. For the ferromagnetic resonance (FMR) a new technique with a microcavity set up has been used. This technique allows to investigate different configurations of particle arrangements and thereby to study in detail the effects of dipolar coupling. The microcavity FMR has a resolution of 10^6 spins [2]. The number of particles was continuously reduced until only single particles remained in the microcavity. FMR at room temperature with a frequency of 9 GHz shows single particle resonance with linewidths of 6 mT. We determined a magnetocrystalline anisotropy $K_4 = (5 \pm 0,5) \cdot 10^3 \frac{J}{m^3}$ which is only 10% of the Fe bulk value. The behaviour of single particles in comparison to a statistical distribution will be discussed on the poster. Financial support by MERCUR (PR-2011-0007) is acknowledged.

[1] Kim et al., JACS, 129, 5812-5813 (2007)
[2] Banholzer et al., Nanotech. 22, 295713 (2011)

MA 16.31 Tue 10:30 Poster D

Experimental investigation and modeling of the spin structure in FePt@MnO heterodimer nanoparticles — •Xiao Sun[1], Alice Klapper[1], Oleg Petracic[1], Oskar Koehler[2], Heiko Bauer[2], Wolfgang Tremel[2], and Thomas Brueckel[1] — [1]Jülich Centre for Neutron Science JCNS-2 und Peter Grünberg Institut PGI-4, Forschungszentrum Jülich GmbH — [2]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg-Universität Mainz

Magnetic nanoparticles (NPs) have attracted much interest for decades. We have focused on FePt@MnO heterodimer NPs consisting of a ferromagnetic FePt particle in contact to an antiferromagnetic MnO particle. Single FePt, single MnO and FePt@MnO dimer NPs with different sizes (5-20nm) have been studied using SQUID magnetometry employing zero field cooled (ZFC)/field cooled (FC) magnetization curves at various fields, hysteresis curves and thermoremanent (TRM)/ isothermoremanent (IRM) curves. An exchange bias effect in dimer particles has been observed by the shift of hysteresis loops at different temperatures suggesting a magnetic coupling between FePt and MnO. An exchange bias shift is not observed in single FePt or MnO NPs. Monte Carlo simulations of the spin structure in single MnO NPs and FePt@MnO dimer NPs are compared to the experimental findings. Neutron scattering experiments aiming to study the spin structure inside single MnO NPs and inside the MnO subunit of FePt@MnO heterodimers using polarized neutron diffraction are proposed.

MA 16.32 Tue 10:30 Poster D

Formation of ferrite nanoparticles monitored during the preparation process by Mössbauer spectroscopy — •Mathias Kraken[1], Nathalie Leise[1], Andre Borchers[1], Dirk Menzel[1], Jochen Litterst[1], Ingke-Christine Masthoff[2], Ilka-Marina Grabs[2], and Georg Garnweitner[2] — [1]Institut für Physik der kondensierten Materie, Technische Universität Braunschweig, 38106 Braunschweig, Germany — [2]Institut für Partikeltechnik, Technische

Universität Braunschweig, Braunschweig, Germany

In the recent years, a broad variety of different preparation methods for magnetic nanoparticles has been established. In this context, the non-aqueous 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 different solvents are placed in a reactor at temperatures above room temperature (typically 200°C). The physical properties of the formed particles depend on the time spent in the reactor.

We investigated solutions of $Fe(acac)_3$ with triethyleneglycol and benzyl alcohol for different reaction times in the reactor by dynamic light scattering, DC susceptibility and Mössbauer spectroscopy in order to gain more information about the process of the formation of the nanoparticles during the stay of the solution in the reactor.

[1] I.-M. Grabs et al., Cryst. Growth Des. 12, 1496 (2012).

MA 16.33 Tue 10:30 Poster D

Characterization of the elastic properties of hydrogels using nickel nanorods as probes — •Philipp Bender, Andreas Tschöpe, and Rainer Birringer — Universität des Saarlandes, Saarbrücken, Germany

With diameters below 42 nm, Ni nanorods are uniaxial ferromagnetic single-domain particles. The nanorods are synthesized by electrodeposition of nickel into porous alumina templates and after several preparation steps dispersed into gelatin gels matrices. Applying a homogeneous magnetic field during gelation results in magnetically textures ferrogels. When the gels are placed in a homogeneous magnetic field, the magnetic torque causes a rotation of the magnetic moments of the rods in field direction. The alignment can occur by a rotation out of the long rod axis working against shape anisotropy or by a rotation of the rods itself, which is restricted by the surrounding elastic network. In a static homogenous magnetic field the magnetic torque, the counteracting torque due to shape anisotropy and the mechanical torque, caused by the shear deformation of the surrounding gel matrix, are at equilibrium. This equilibrium condition was used to develop several methods to characterize the elastic properties of soft hydrogel matrices by magnetization measurements using nickel nanorods as probes. In the present study the initial susceptibilty of the magnetization curves is evaluated in order to determine the shear modulus.

MA 16.34 Tue 10:30 Poster D

Enhanced anisotropy of Ni nanoparticles embedded in IrMn matrices — •Balati Kuerbanjiang[1], Ulf Wiedwald[2], Felix Häring[2], Johannes Biskupek[3], Ute Kaiser[3], and Ulrich Herr[1] — [1]Inst. of Micro and Nanomaterials, Ulm University, 89081 Ulm — [2]Inst. of Solid State Physics, Ulm University, 89069 Ulm — [3]Electron Microscopy Group of Materials Science, Ulm University, 89081 Ulm

Magnetic nanoparticles have huge potential in future applications such as data storage, nanosensors and biomedicals. However, superparamagnetic effect puts a limit on the minimum size of the particles in terms of usage. One way to overcome this limit is attaining exchange anisotropy by coupling the ferromagnetic (FM) particles to an antiferromagnetic (AFM) media. Different from most of the literature works, we developed a sample preparation system where we can independently change the type of FM and AFM materials, allowing us to study the effect in a flexible way. In this work, we have produced Ni nanoparticles using plasma gas condensation technique and *in-situ* embedded them in an IrMn matrix. We show that the embedded Ni nanoparticles display enhanced coercivity H_c and exchange bias H_{ex}. Furthermore, we find that the effect is stronger in smaller particles, and the extracted exchange energy values are in the range of the values found in FM/IrMn bilayer systems. The particle size dependencies of H_c and H_{ex} have been measured in detail, and we propose a micromagnetic model to describe the observed trends. By conducting FC/ZFC measurements, we show a clear increase of blocking temperature for embedded particles compared to identical non-embedded particles.

MA 16.35 Tue 10:30 Poster D

Quadratic magnetooptical effects in two-dimensional permalloy particles investigated by scanning X-ray microscopy — •S.A. Nepijko[1], O.V. Pylypenko[2], L.V. Odnodvorets[2], E. Kisker[3], H.J. Elmers[1], and G. Schönhense[1] — [1]Institute of Physics, University of Mainz, Staudingerweg 7, 55128 Mainz, Germany — [2]Sumy State University, Rimsky-Korsakov str. 2, 40007 Sumy, Ukraine — [3]Institute of Applied Physics, University of Düsseldorf, Universitätsstrasse 1, 40225 Düsseldorf, Germany

We have investigated the magnetization structure and magnetization curves of individual rectangularity shaped permalloy particles using scanning X-ray microscopy in the ultrasoft X-ray regime. Magnetic contrast originates from M-edge X-ray magnetic circular dichroism and from the transverse magnetooptical Kerr effect [1, 2]. We studied magnetization curves in dependence on the field direction for particles of different shapes and sizes. Adjacent particles cause a significant dipole interaction. Asymmetric magnetization loops indicate the presence of non-linear magnetooptical effects. [1] M. Schroeder et al., Nucl. Instrum. Methods Phys. Res., Sect. A, 467-468 (2001) 1404; [2] S.A. Nepijko et al., APA, published online: 19 Sept. 2012

MA 16.36 Tue 10:30 Poster D

Towards EMCD measurements of non-crystalline materials — •Jan Rusz[1], Shunsuke Muto[2], Vancho Kocevski[1], and Kazuyoshi Tatsumi[2] — [1]Department of Physics and Astronomy, Uppsala University, Sweden — [2]Department of Materials, Physics and Energy Engineering, Nagoya University, Japan

Electron magnetic circular dichroism (EMCD) is a young experimental technique that brings a promise of measurement of atom-specific magnetic characteristics at sub-nanometer resolution - an information that is not accessible by any other experimental technique yet. We propose a method of circumventing one of its major present obstacles, namely, the high demands on the quality of measured samples. Until now, only single-crystal samples could be measured. Those had to be oriented in a specific geometry, in order to exploit symmetries of the measurement set up. In the newly proposed method, theoretically analysed in Muto, Tatsumi, Rusz, Ultramicroscopy (in press), the symmetry requirements and specific orientations are effectively removed. Moreover, the method unveiled an exciting possibility to measure polycrystals and possibly even amorphous magnets. The method is based on modern methods of statistical analysis of the multivariate datasets, namely the multivariate curve analysis method (Tauler, 1995). Based on theoretical simulations we explore the feasibility of EMCD experiments on polycrystals and amorphous materials.

MA 16.37 Tue 10:30 Poster D

Exchange Bias in all-Manganite $La_{0.7}Sr_{0.3}MnO_3/SrMnO_3/La_{0.7}Sr_{0.3}MnO$ Trilayers — •Markus Jungbauer, Sebastian Hühn, Markus Michelmann, Camillo Ballani, and Vasily Moshnyaga — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

A great interest to exchange bias phenomenon in artificially layered thin films is caused by fundamental importance of this well-known but still controversially explained effect as well as by its promising applicability in spintronics (TMR and multiferroics). We studied exchange bias for all-manganite $La_{0.7}Sr_{0.3}MnO_3/SrMnO_3/La_{0.7}Sr_{0.3}MnO_3$ trilayers with ferromagnetic $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) and G-type antiferromagnetic $SrMnO_3$ (SMO) layers, grown on (001) $SrTiO_3$ substrates by metalorganic aerosol deposition (MAD). The field shift of the magnetic hysteresis loop H_E and the coercitivity H_C decay exponentially with temperature, vanishing at $T = 100\,K$. H_E exhibits a global maximum as a function of the SMO interlayer thickness at $t_{SMO} \approx 4.5\,nm$. We argue that the EB behaviour can be explained by the interplay of a spinglass state at the interface and theoretically proposed mechanism based on the Dzyaloshinskii-Moriya interaction[1]. Financial support of EU via FP7 (IFOX) is acknowledged.

[1] S. Dong, et al., Phys. Rev. Lett. **103**, 127201 (2009)

MA 16.38 Tue 10:30 Poster D

Magneto-resistive characterization of hybrid magnetic films — •Kadir Sentosun[1], Julia Trützschler[1], Manuel Langer[2], Ingolf Mönch[3], Roland Mattheis[4], Thomas von Hofe[1], Jurgen Fassbender[2], and Jeffrey McCord[1] — [1]Institute for Material Science, University Kiel, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [3]Leibniz Institute for Solid State and Materials Research, Dresden, Germany — [4]Institute of Photonic Technology, Jena, Germany

Thin films with an initial unidirectional anisotropy are patterned by ion irradiation [1] into stripe-like two dimensional structures with alternating directions of exchange bias (EB). By this a structure with laterally varying perpendicular alignment of EB is obtained. The magnetization behaviour of the NiFe/IrMn thin films is investigated by complementary methods: Structures of different stripe width are analysed by inductive magnetometry, the change of anisotropic magneto-resistance (AMR) with varying field angles is investigated by a four probe con-

tact measurement technique, and the magnetization reversal is studied by Kerr microscopy. Transversal magnetization components related to domain wall activity are derived from the AMR measurements. The characteristic AMR sensitivity is maximized when the measuring current direction is along the net magnetization, also oriented parallel to the applied magnetic field direction. Pure uniaxial magnetic field sensitivity is obtained through the perpendicularly aligned magnetization modulation. [1] J. Fassbender and J. McCord, J. Magn. Magn. Mater. 320, 579-596 (2008)

MA 16.39 Tue 10:30 Poster D

Preparation of epitaxial FeMn/Co-exchange-bias systems on MgO single crystals — •Mathias Schmidt, Patrick Audehm, Eberhard Goering, and Gisela Schütz — Max-Planck-Institut für Intelligente Systeme, Heisenbergstr. 3, 70569 Stuttgart

Exchange bias systems are very important for several applications in the area of magnetic storage media. Inside that class of materials, FeMn/Co-thin films are one of the most prominent examples. For research issues, they are usually produced on Cu single crystals fitting almost perfectly to the lattice constant of FeMn, leading to epitaxial growth. For receiving a deeper understanding of the exchange-bias, which is still under strong debate, we used different methods as SQUID, AFM and MOKE but also XAS, XMCD and XRMR (X-Ray Magnetic Reflectometry). Because of the weak deformation resistance of Cu substrates, especially the latter method is nearly impossible to access, which is in principle necessary to receive a detailed magnetic and physical depth profile of the sample. Molecular beam epitaxy was used to produce FeMn/Co-systems on (100) MgO substrates. With the help of different buffer layers, we could achieve epitaxial properties through all sample layers, creating well defined interfaces. We will present the preparation process and the results of multiple characterization methods revealing new insights into the physical and magnetic properties of these exchange-bias systems.

MA 16.40 Tue 10:30 Poster D

Ferromagnetic-antiferromagnetic transition in 1D Fe-based nanocontacts — •Ilia N. Sivkov[1], Dmitriy I. Bazhanov[2], and Valeriy S. Stepanyuk[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Physics Department, Moscow State University, Moscow, Russia

The recent progress in nanoelectronics and spintronics leads to an intensive experimental and theoretical study of spinpolarized electron transport in one-dimensional nanostructures - nanowires and nanocontacts. The spin-polarized electron transport through mixed magnetic nanostructures can increase significantly the data recording and transmission densities without increasing the size of nanostructures. In our recent study we have shown that it is possible to create the stable mixed Pd-Fe nanowires which exhibit a ferromagnetic-antiferromagnetic(FM-AFM) transition during stretching. We investigate this phenomena in finite atomic mixed chains suspended between Pt, Pd and Au leads using density functional theory. The spin-dependent transmission calculation was performed using non-equilibrium Green's function method and density functional theory. Effect of FM-AFM transition on conductance and magnetoresistance is discussed.

MA 16.41 Tue 10:30 Poster D

influence of top Ni layer on exchange bias and blocking temperature in Ni/NiMn/Ni trilayers — •yasser shokr[1], mustafa erkovan[1,2], Daniela schiestl[1], chii-bin wu[1], mohammed yaqoob khan[1], and wolfgang kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany. — [2]Gebze Institute of Technology, Dept. of Physics, 41400 Kocaeli, Turkey

The exchange bias (EB) field and the blocking temperature for exchange bias (Tb) in the system Y ML Ni/X ML Ni25Mn75/12 ML Ni on Cu3Au(001) were investigated by magneto-optical Kerr effect (MOKE). The study concentrates on the influence of the antiferromagnetic (AFM) layer thickness on the EB field and on Tb. For every AFM layer thickness X the top ferromagnetic (FM) layer thickness Y has been changed from 0ML and then 12 ML to 22 ML in steps of 5 ML. we show that the EB field is reduced after deposition of the top Ni layer. This is interpreted in term of pining of uncompensated moments in the volume of the AFM layer. In addition, magnetic interlayer coupling between the two Ni layers influence the EB field.

MA 16.42 Tue 10:30 Poster D

Magnetic excitations in half- and overdoped manganites — Holger Ulbrich[1], •Thomas Bardenheuer[1], Paul Steffens[2], Yvan Sidis[3], Daniel Lamago[3], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln, 50937 Köln — [2]Institut Laue Langevin, Grenoble — [3]Laboratoire Léon Briilouin, CE Saclay, Gif sur Yvette Cedex

Magnetic excitations were studied by inelastic neutron scattering on various manganites that exhibit charge, orbital and spin ordering. At half-doping the magnetic excitation spectra can be perfectly modelled by a simple Heisenberg model of magnetic interaction which perfectly agrees with the Goodenough scenario of charge and orbital ordering. There seems to be no qualitative difference in all the half-doped manganites studies so far irrespective of their layered or three-dimensional character. For higher doping we observe a stripe-like arrangement of the electronic and magnetic ordering. Furthermore the magnetic excitation spectra closely resemble the hour-glass like dispersion observed in many high-temperature superconducting cuprates. Besides a large ratio of intra- to inter-stripe magnetic inteaction parameters, a short range of the magnetic ordering perpendicular to the stripes can be identified as decisive parameter to induce a hour-glass dispersion in insulating stripe phases.

[1] H. Ulbrich et al., Phys. Rev. Lett. **106**, 157201 (2011) [2] H. Ulbrich, Phys. Rev. B **84**, 094453 (2011) [2] H. Ulbrich, Phys. Rev. Lett. **108**, 247209 (2012)

MA 16.43 Tue 10:30 Poster D

Test of band structure calculations for Heusler compounds by spin-resolved photoemission spectroscopy — Michaela Kolbe[1], Stanislav Chadov[2], Elena Arbelo Jorge[1], Gerd Schönhense[1], Claudia Felser[2], Hans-Joachim Elmers[1], Mathias Kläui[1], and •Martin Jourdan[1] — [1]Institut für Physik, Johannes Gutenberg-Universität, Staudingerweg 7, 55128 Mainz — [2]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden

The electronic density of states of epitaxial thin films of the Heusler compound Co_2MnGa is probed in situ by spin-resolved ultraviolet photoemission spectroscopy. The experiments reveal several characteristic features in the intensity spectrum and a clear Fermi edge signature. A high spin polarization of 55% at the Fermi edge is followed by a sign change at the binding energy of 0.8 eV. Corresponding calculations of the band structure and the photoemission spectrum were performed employing a spin-polarized relativistic Korringa-Kohn-Rostoker code. Good agreement between the experimental data and calculations was obtained, including dynamical correlation effects [1].

[1] M. Kolbe et al., Phys. Rev. B, 86, 024422 (2012)

MA 16.44 Tue 10:30 Poster D

Carbon Nanotubes filled with Nanoparticles from the System Ni-Mn-Ga — •Marcel Haft, Silke Hampel, Markus Gellesch, Sabine Wurmehl, Lars Giebeler, Maria Dimitrakopolou, and Bernd Buechner — Leibniz-Institute for Solid State and Materials Research, IFW-Dresden, D-01171

Properties of nanoscale materials can completely change when scaling a bulk-material down to its smallest size. However, especially at nanoscale dimensions oxidation is a fundamental challenge in intermetallic materials, which has so far obstructed the investigation of attractive intermetallic materials at the nanoscale. In this work, we propose a novel approach for the synthesis of intermetallic (magnetic) nanoparticles which is based on the encapsulation of materials inside carbon nanotubes. Hereby carbon nanotubes function as a template for the formation of nanoparticles and nanowires with well-defined sizes and provide protective carbon shells which hinder oxidation of the nanoparticles. We present several wet chemical filling methods, both from solution and from melt of metal nitrates and halides. The samples were well characterized by means of electron microscopy (SEM, TEM), x-ray probes and temperature dependent magnetometry. We observe, that the metallic nanoparticles inside carbon nanotubes exhibit enhanced magnetic performance (increased coercitivity) compared to bulk material. So far Nickel, Manganese and Gallium were filled separately into carbon nanotubes as model compounds. In future we will fill nanoparticles of the respective binary compounds and eventually also the ternary Heusler compound Ni2MnGa into carbon nanotubes.

MA 16.45 Tue 10:30 Poster D

Interface-controlled Magnetism and Transport of Ultrathin Manganite Films — •Sebastian Hühn[1], Markus Jungbauer[1], Markus Michelmann[1], Oleg Shapoval[2], Alexander Belenchuk[2], Jo Verbeeck[3], and Vasily Moshnyaga[1]

— [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany, — [2]IIEN, Academy of Sciences of Moldova, Academiei str., 3/3, MD-2028, Chisinau, Moldova — [3]EMAT, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium

The recent great fundamental and technological interest for interfaces in thin films of correlated oxides (manganites, aluminates, titanites and cuprates) is caused by two main reasons: 1) to stabilize the bulk-like magnetism, metallicity and ferroelectricity in ultrathin films and 2) to create new interface-originated properties not akin to the bulk phases. We investigate thin ferromagnetic manganite films with various interface modifications grown by metalorganic aerosol deposition (MAD) technique on $SrTiO_3$ substrates with different orientations. Structure and morphology is studied by AFM/STM, XRD, XRR and HREM; transport and magnetization by PPMS and MPMS, respectively. We observe ferromagnetic metallic behavior of a three unit cell thick interface engineered lanthanum manganite film, modified by 2 u.c. of strontium manganite, grown on STO(100). Financial support from EU FP 7, IFOX (interfacing oxides) project is acknowledged.

MA 16.46 Tue 10:30 Poster D

Magnetic resonance study of Heusler compounds — •A. Alfonsov[1], S. Rodan[1], M. E. Belesi[1], V. Kataev[1], B. Peters[2], F. Yang[2], M. Emmel[3], G. Jakob[3], H.-J. Elmers[3], S. Wurmehl[1], and B. Büchner[1] — [1]IFW Dresden, D-01169 Dresden, Germany — [2]Department of Physics, Ohio State University,191 West Woodruff Avenue Columbus, Ohio 43210, USA — [3]Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany

Heusler alloys have attracted a considerable attention in recent years since these compounds are predicted to be halfmetallic ferromagnets. High magnetic moments and high values of the Curie temperature give them a significant potential for spintronics applications. To control the macroscopic physical properties of these materials it is crucial to have a precise knowledge of the structural and magnetic ordering also on a local scale. For instance, the halfmetallicity in these materials strongly depends on the local atomic order. To obtain such knowledge one has to call for local probe techniques. In this work we present recent nuclear magnetic resonance and electron spin resonance study of various Co-, Mn- and Fe-based Heusler compounds where we address the local structural and magnetic properties.

MA 16.47 Tue 10:30 Poster D

The influence of p- and n-doping on the intrinsic properties of the Heusler compound Fe_2VAl — •Franziska Seifert[1,2], Christian G.F. Blum[1], Frank Steckel[1], Christian Hess[1], Bernd Büchner[1], Sabine Wurmehl[1], Stefan Martin[2], and David Rafaja[2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden — [2]TU Bergakademie Freiberg, Germany

The Heusler compound Fe_2VAl is considered as a non-magnetic thermoelectric material. In this work, we studied the intrinsic properties of the Heusler compound Fe_2VAl and the influence of p- and n-doping on the intrinsic materials properties of the corresponding Si and Ti doped compounds using single crystals. Electron back scattering diffraction reveals the presence of a V-rich secondary phase in particular in crystals with Si and in the parent compound. The depletion of V from the Fe_2VAl matrix apparently leads to localized Fe moments and to ferromagnetism in the corresponding samples. Interestingly, the sample with Ti and less V depletion shows a significant enhancement of the figure of merit compared to the other samples.

MA 16.48 Tue 10:30 Poster D

First-principles study of the structural stability of Mn_3Z (Z=Ga, Sn and Ge) Heusler compounds — •D. Zhang[1], B. Yan[1,2], S.-C. Wu[1], J. Kuebler[3], G. Kreiner[1], and C. Felser[1,2] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Johannes Gutenberg-Universität Mainz, Staudingerweg 9, 55128 Mainz, Germany — [3]Institut für Festkörperphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany

We investigate the structural stability and magnetic properties of cubic, tetragonal and hexagonal phases of Mn_3Z (Z=Ga, Sn and Ge) Heusler compounds using the first-principles density-functional theory. We propose that the cubic phase plays an important role as an intermediate state in the phase transition from the hexagonal to the tetragonal phase. Consequently, Mn_3Ga and Mn_3Ge behave differently from Mn_3Sn, because the relative energies of the cubic and hexagonal phases are different. These results agree with experimental observations from these three compounds. The weak ferromagnetism of the hexagonal phase and the perpendicular magnetocrystalline anisotropy of the tetragonal phase obtained in our calculations are also consistent with experiment.

MA 16.49 Tue 10:30 Poster D

Autocorrelation measurement with femtosecond laser pulses of correlated polaron dynamics in manganites — •Manuel Mchalwat, Christin Kalkert, Camillo Ballani, Vasily Moshnyaga, Markus Münzenberg, and Konrad Samwer — 1. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

In manganites the spatial and time scales of correlations range from microns and seconds as for the electronic phase separation down to 1 . . . 2 nm and femtoseconds as for the Jahn-Teller polarons. Recently it was shown that the third harmonic voltage in electrical transport is proportional to the concentration of correlated polarons. To get access to the their ultrafast dynamics we performend an autocorrelation measurement of the third harmonic voltage with femtosecond laser pulses thus photo-inducing correlated polarons. Further we discuss our results with respect to thermal and non-thermal influences.

The work has been supported by the DFG through SFB 602 TP A2 and by Femtolasers.

MA 16.50 Tue 10:30 Poster D

Theoretical study of the mechanical stability and magnetic properties of Mn_2-based Heusler compounds with heavy transition metals — •L. Wollmann[1,2], G. H. Fecher[1], and C. Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Straße 40, 01187 Dresden, Germany — [2]Johannes Gutenberg University, Staudingerweg 9, 55128 Mainz, Germany

We have investigated by ab-initio calculations the class of Mn_2YZ Heusler compounds (with Y = Rh, Ru and Z = Ga, In, Tl, Ge, Sn, Pb) in order to explore their potential for applications in the field of spintronics. The calculations have been performed using the FPLAPW+(lo)-method as implemented in Wien2k. By applying uniaxial strain in the linear region in three directions it was possible to evaluate the mechanical stability. Proving that they do not adapt the cubic Heusler structure by evaluating the elastic properties, we report to have found promising candidates for new Heusler phases (tetragonal or lower symmetry) formed by the mentioned compositions. The mechanical properties, as well as the electronic and magnetic structure of tetragonal and cubic compounds will be discussed.

MA 16.51 Tue 10:30 Poster D

Magnetic and transport properties of the Heusler system $Ni_{2-x}Mn_{1+x}Sn$. — •Tina Fichtner, Guido Kreiner, Gerhard H. Fecher, Walter Schnelle, and Clauida Felser — Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden

In the present work we have investigated a new series of polycrystalline alloys of the general composition $Ni_{2-x}Mn_{1+x}Sn$ with x = 0, 0.2, 0.4, 0.5, 0.6, 0.8, 1. The alloys were obtained as single-phase materials by inductive melting of the elements and subsequent annealing at 700°C. $Ni_{2-x}Mn_{1+x}Sn$ crystallizes in the cubic Heusler structure, thus forming a solid solution series from Ni_2MnSn to Mn_2NiSn. The stochiometric Heusler compounds of this series show ferro- or ferrimagnetic order with T_c ranging from 346 to 550 K, respectively. The magnetic moment at 1.8 K decreases in the series from 4.1 μ_B to 2.3 μ_B. The cubic symmetry is stable from low to high temperature. Instead of building a non-cubic structure, a miscibility gap forms pointing out an entropic stabilization of the cubic phase. Here, we report on the magnetic and transport properties with respect to the chemical disorder.

MA 16.52 Tue 10:30 Poster D

Electronic, structural and magnetic properties of $NiFe_2O_4$ ultra thin films — •Michael Voigt[1], Christian Caspers[1], Bernardus Zijlstra[1], Sebastian Flade[1], Sven Döring[2], Mihaela Gorgoi[3], Claus M. Schneider[1], and Martina Müller[1] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich — [2]Experimentalphysik, Universität Duisburg-Essen — [3]BESSY II, Helmholtzzentrum Berlin für Materialien und Energie

The spinel $NiFe_2O_4$ (NFO) is an insulating oxide that is ferrimagnetic with a Curie-temperature way above room temperature. This rare combination of properties makes this material intriguing for integration into heterostructures for spintronics. The magnetic properties of ultra-thin ferrite films, however, strongly differ from the bulk, i.e. an

enhanced magnetization is observed for $d_{NFO} \leq 10$ nm, though the reason for this is still unclear.
To gain insights into this phenomenon, we investigated ultra-thin NFO films (d = 2 - 20 nm) deposited on $SrTiO_3$ via pulsed laser deposition, and studied the structural, magnetic and electronic properties via SQUID, XRD, NEXAFS and HAXPES. The latter two methods allow us to probe the oxidation states and the atomic coordination element specifically for the Ni- and Fe-cations. The Ni- & Fe-2p/3p spectra show that the ultra-thin films grow with bulk-like electronic properties. From the spectral shape we conclude, that even for lowest film thickness no cation inversion takes place. Furthermore, we deduce a two-phase growth mode from XRD data, in which NFO grows highly strained for d $\leq$ 4 nm and starts to relax for larger thicknesses.

MA 16.53 Tue 10:30 Poster D

Structural and magnetic properties of Ni-Co-Mn-Sn thin films — •Ramudu Machavarapu, Christian Mix, and Gerhard Jakob — Institut für Physik, Johannes Gutenberg-Universität Mainz, 55128 Mainz

Ni-Co-Mn-Sn alloys have drawn interest recently due to their multifunctional properties like magnetic shape memory effect (MSME), magnetocaloric effect and direct conversion of heat to electricity. It is well recognized that the austenite of the Ni-(Co)-Mn-X (X = In, Sn, Sb) alloys has a ferromagnetic state below the Curie temperature (TC) and a paramagnetic state above TC. However, the low-temperature martensite exhibits different magnetic behavior such as ferromagnetic, paramagnetic, antiferromagnetic and spin glass, depending on exact composition. These alloys also have shown thermoelastic martensitic transformations at high temperatures. To gain a deep understanding of the functional properties of these alloys, it is very important to investigate their structural and magnetic properties in detail.

Thin films of Ni-Co-Mn-Sn have been prepared on single crystalline MgO (100) substrate using DC magnetron sputtering. The preparation parameters like sputtering power, substrate temperature and argon gas pressure were optimized. Crystal structure of thin films was studied using X-ray diffraction. Detailed structural transformations and magnetic properties were investigated using superconducting quantum interference device (SQUID) magnetometer.

We acknowledge financial support by the DFG within priority program SPP 1239 (Ja821/3-3).

MA 16.54 Tue 10:30 Poster D

Zero Field ^{55}Mn NMR study of Ni-Mn-Ga shape memory alloys — •Maria Eleni Belesi, Christian G. F. Blum, Bernd Büchner, and Sabine Wurmehl — Leibniz Institute for Solid State and Materials Research, Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany

Ferromagnetic shape memory alloys exhibit a structural transition from the high temperature austenitic phase to the low temperature martensitic phase. The structural transition can be driven either by temperature or by a magnetic field. Nuclear Magnetic resonance (NMR) is a powerful local technique which is well known to provide information on the static and dynamic phenomena accompanying structural phase transitions. We have performed ^{55}Mn NMR experiments at zero magnetic field on as-cast and annealed Ni-Mn-Ga samples prepared by arc melting. The evolution of the local structure from the high temperature austenitic phase to the low temperature martensitic phase is probed ^{55}Mn NMR lineshape measurements.

MA 16.55 Tue 10:30 Poster D

Martensitic Transition in Ni-Mn-Ga/Ni-Mn-Sn Multilayer Thin Films — •Niclas Teichert[1], Anna Möhn[2,3], Anja Waske[3], Biswanath Dutta[4], Tilmann Hickel[4], and Andreas Hütten[1] — [1]Department of Physics, Thin Films and Physics of Nanostructures, Bielefeld University, 33615 Bielefeld, Germany — [2]IFW Dresden, Institute for Complex Materials, 01069 Dresden, Germany — [3]TU Dresden, Institut für Festkörperphysik, 01062 Dresden, Germany — [4]Max-Planck-Institut für Eisenforschung GmbH, 40237, Düsseldorf, Germany

Both Ni-Mn-Sn and Ni-Mn-Ga are ferromagnetic shape-memory Heusler alloys and show a martensitic transition accompanied by a magnetocaloric effect (MCE) in a certain composition range. The MCE is inverse in Ni-Mn-Sn and conventional in Ni-Mn-Ga. We want to achieve a coupling of both effects in multilayer thin films in order to enhance the MCE. This approach gives rise to additional interface entropy, magnetic interaction across the interfaces and lateral strain due to the lattice mismatch.

We prepared different epitaxial Ni-Mn-Ga/Ni-Mn-Sn multilayer thin films on heated MgO(001) substrates by magnetron sputtering. The number of layers as well as the layer thickness is varied to study the effects of interfaces, strain and interdiffusion between the layers on the martensitic transition. This is done by temperature dependent resistivity and magnetoresistance measurements, magnetic measurments, X-Ray diffraction and Auger electron spectroscopy.

MA 16.56 Tue 10:30 Poster D

Tunnel magneto-Seebeck effect in tunnel junctions with perpendicular magnetic anisotropy — •Tim Eggebrecht[1], Marvin Walter[1], Vladyslav Zbarsky[1], Markus Münzenberg[1], Volker Drewello[2], Karsten Rott[2], Günter Reiss[2], Andy Thomas[2], Patrick Peretzki[3], Michael Seibt[3], Michael Czerner[4], Michael Bachmann[4], and Christian Heiliger[4] — [1]I. Physikalisches Institut, Universität Göttingen — [2]Department of Physics, Bielefeld University — [3]IV. Physikalisches Institut, Universität Göttingen — [4]I. Physikalisches Institut, Universität Giessen

In CoFeB/MgO/CoFeB tunnel junctions (MTJs) with in-plane magnetic anisotropy the tunnel magneto-Seebeck effect (TMS) has already been observed. Recently, MTJs with perpendicular magnetic anisotropy (PMA) were fabricated by reducing the thickness of the two CoFeB layers. The thickness has to be lower than 1.3 nm, as observed by other groups. These MTJs with 4 monolayers MgO barrier show a TMR of more than 40 % and a very low switching current density of $2 \cdot 10^5$ A/cm^2.

In this work, the tunnel magneto-Seebeck effect is studied in junctions with in-plane and perpendicular magnetic anisotropy. The heating is achieved with a diode laser which delivers powers of up to 150 mW. The influence of the thin CoFeB layers and the MgO barrier on the TMS is studied.

MA 16.57 Tue 10:30 Poster D

HF-ESR studies of the compounds $\{[Cu(bpy)_3][Cu_2(C_2O_4)_3]\cdot H_2O\}_n$ and $\{[Cu(bpy)_3][Mn_2(C_2O_4)_3]\cdot H_2O\}_n$ — •Dijana Žilić[1,2], Boris Rakvin[2], Marijana Jurić[2], Pavica Planinić[2], Damir Pajić[3], Krešo Zadro[3], Yulia Krupskaya[1], Vladislav Kataev[1], and Bernd Büchner[1] — [1]Leibniz Institute for Solid State and Materials Research IFW Dresden, Dresden, Germany — [2]Rudjer Bošković Institute, Zagreb, Croatia — [3]Faculty of Science, University of Zagreb, Zagreb, Croatia

The homometallic $\{[Cu(bpy)_3][Cu_2(C_2O_4)_3]\cdot H_2O\}_n$ (**1**) and the heterometallic $\{[Cu(bpy)_3][Mn_2(C_2O_4)_3]\cdot H_2O\}_n$ (**2**) compounds, where bpy = 2,2'-bipyridine, consist of a three-dimensional (3D), polimeric anionic network $[M_2(C_2O_4)_3]_n{}^{2n-}$ (where M = Cu^{2+} or Mn^{2+}) with cations $[Cu(bpy)_3]^{2+}$ occupying the vacancies of the network.

Frequency- and temperature-dependent high field electron spin resonance (HF-ESR) measurements on a polycrystalline sample of **1** and **2** are presented. Supported by X-band ESR on the polycrystalline of **1** and on the single crystal of **2**, as well as, SQUID magnetization measurements, the magnetic properties of the compounds **1** and **2** are discussed.

MA 16.58 Tue 10:30 Poster D

Domain-structure-induced giant magneto-impedance — •Matthäus Langosch, Thomas Karwoth, Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P. O. Box 151150, D-66041, Saarbruecken, Germany

Recent magneto-impedance studies in the low frequency range up to 100 kHz confirm the GMI effect on <100> iron single crystals (iron whiskers) [1]. In this range, contributions of magnetic domain structures and domain wall dynamics have to be taken into account. Compared to optimized GMI samples like amorphous Co-based microwires, iron whiskers have cubic magneto crystalline anisotropy and the GMI effect shows a strong current dependence. The dependence is related to the Oersted-field-induced domain structure when the current is in the order of tens of mA. The magnitude and the phase of the effective circumferential permeability, obtained through calculations based on the standard skin effect formalism and the experimental data, show various magnetic field and current frequency regimes. Further experimental investigations including magneto-optical Kerr effect microscopy and pickup-coil measurements give a deeper insight in these GMI regimes.

[1] M. Langosch, H. Gao and U. Hartmann J. Phys. D: Appl. Phys. 45, 085001 (2012)

MA 16.59 Tue 10:30 Poster D

Giant magnetoimpedance of composite wires with an insulation layer — Ralf Betzholz[1], •Haibin Gao[1], Zhenjie Zhao[2], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, Saarland University, P.O. Box 151150, D-66041 Saarbruecken, Germany — [2]Department of Physics, East China Normal University, 3663 Zhongshan North Road, 200062 Shanghai, P.R. China

Composite wires with a three-layered structure were investigated with regard to the origin of the giant magnetoimpedance (GMI) effect. The samples consisting of a copper core, a silicon dioxide layer and an outer Permalloy shell were prepared by RF magnetron sputtering. The GMI ratio was measured at various driving current frequencies and with different insulating layer thicknesses. A theoretical model based on coupling the Maxwell equations to the Landau-Lifschitz-Gilbert equation was developed to investigate the composite wire impedance and its dependence on external magnetic field, current frequency and insulating layer thickness. Reasons for discrepancies between the theory and experimental findings were discussed.

MA 16.60 Tue 10:30 Poster D

First-principles study of inorganic-organic hybrids: $(NH_4)_2CuCl_4$, $(CH_3NH_3)_2CuCl_4$ and $(C_2H_5NH_3)_2CuCl_4$ — •Pegah Zolfaghari[1], Gilles A de Wijs[1], and Robert A de Groot[1,2] — [1]Radboud university Nijmegen, Electronic Structure of Materials,Institute for Molecules and Materials, Netherlands — [2]Rijksuniversiteit Groningen, Solid State Materials for Electronics,Zernike Institute for Advanced Materials, Netherlands

Hybrid inorganic-organic compounds with the general formula $(C_nH_{2n+1}NH_3)_2CuCl_4$ are an interesting class of new materials in condensed matter physics. These materials provide a considerable opportunity for scientific studies. The ferromagnetic intra-layer interactions in Cu^{2+} organic-inorganic hybrids enable magnetic applications in electronic devices. The organic blocks are essential for the synthesis by the self-assembly. We report electronic structure calculations based on first principles methods as well as the LDA+U method. A linear relation between the intra-layer interaction and tilting of the $[CuCl_6]^{4-}$ octahedra is observed. The magnetic coupling between the octahedra shows a weak quasi 2-D nearest neighbor character. This results in relatively low Curie temperatures.

MA 16.61 Tue 10:30 Poster D

Origin of the Giant Magnetocaloric effect — •Prasenjit Roy[1], Gilles A de Wijs[1], and Robert A de Groot[1,2] — [1]Electronic Structure of Materials, Radboud University Nijmegen, Institute for Molecules and Materials, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands — [2]Laboratory of Chemical Physics, Zernike Institute of Advanced Materials, Nijenborgh 4, NL-9747 AG Groningen, The Netherlands

Adiabatic demagnetization as tool for refrigeration at room temperature has been studied extensively over the past decade. Recently the origin of the colossal magneto-caloric effect has been discovered by electronic structure calculations: the coexistence of weak and strong magnetism in one compound: mixed magnetism. Current research focuses on the study of the relation between structure, chemical composition and details of the mixed magnetism in the MnFePSi systems, with emphasis on the behavior of the weakly magnetic part of the compounds.

MA 16.62 Tue 10:30 Poster D

Investigation of the magnetocaloric effect in La(Fe,Si,Co)13 compound in pulsed magnetic fields — •Mahdiyeh Ghorbani Zavareh[1,2], Iurii Scurschii[1], Konstantin Skokov[3], Oliver Gutfleisch[3], and Joachim Wosnitza[1] — [1]HZDR Institute of Ion-Beam Physics and Materials Research P.O. Box 510119, 01314 Dresden, Germany — [2]TU Dresden Helmholtzstr. 10, 01069 Dresden, Germany — [3]Materials Science, Technical University Darmstadt, Petersenstr. 23, 64287 Darmstadt, Germany

We report on direct measurements of the magnetocaloric effect (MCE) of La(Fe,Si,Co)13 compound, which belongs to a family of materials prospective for magnetic refrigeration applications. Measurements in quasi-static magnetic fields up to 2 Tesla have shown the change of temperature up to 6 K. A new technique of measuring the MCE directly in pulsed magnetic field has been developed. This allows to investigate MCE in magnetic fields up to 70 Tesla. The set-up has been tested by measuring MCE of polycrystalline gadolinium. We have measured MCE of La(Fe,Si,Co)13 compound in the fields up to 10 Tesla. The data obtained are in a good agreement with the quasi-static data.

MA 16.63 Tue 10:30 Poster D

Investigation of the magnetocaloric effect in La(Fe,Si,Co)13 compound in pulsed magnetic fields — •Mahdiyeh Ghorbani Zavareh[1,2], Iurii Scurschii[1], Konstantin Skokov[3], Oliver Gutfleisch[3], and Joachim Wosnitza[1] — [1]Dresden High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden Rossendorf, D-01314 Dresden, — [2]TU Dresden Helmholtzstr. 10, 01069 Dresden, Germany — [3]Materials Science, Technical University Darmstadt, Petersenstr. 23, 64287 Darmstadt, Germany

We report on direct measurements of the magnetocaloric effect (MCE) of La(Fe,Si,Co)13 compound, which belongs to a family of materials prospective for magnetic refrigeration applications. Measurements in quasi-static magnetic fields up to 2 Tesla have shown the change of temperature up to 6 K[1]. A new technique of measuring the MCE directly in pulsed magnetic field has been developed. This allows to investigate MCE in magnetic fields up to 70 Tesla. The set-up has been tested by measuring MCE of polycrystalline gadolinium. We have measured MCE of La(Fe,Si,Co)13 compound in the fields up to 10 Tesla. The data obtained are in a good agreement with the quasi-static data.[1]J. Lyubina, O. Gutfleisch, M. D. Kuz'min, and M. Richter, J. Magn. Magn. Mater. 321, 3571 (2009).

MA 16.64 Tue 10:30 Poster D

Magnetic and Structural investigation of high performance Rare earth permanent magnets — •Sapana Tripathi, Eberhard Goering, Gisela Schütz, and Dagmar Goll — Max Planck Institut für Intelligente Systeme, Heisenbergstr. 3 ,70569 Stuttgart

The study of rare earth permanent magnets has a great importance from the viewpoints of both academic research and large variety of applications in modern technologies. The most powerful permanent magnetic material at present which derive their exceptional magnetic characteristic from the favorable combination of rare earth metal is Neodymium-Iron-Boron (Nd,Dy)2Fe14B magnets. In order to clarify the contribution of rare earth elements in magnetism, the magnetic characteristics have been determined quantitatively from X-ray magnetic circular dichroism (XMCD) , element specific hysteresis loops and magnetic moments using our new 7 Tesla magnet XMCD system, which is able to saturate the (Nd,Dy)2Fe14B magnets. Further investigations related to the micro structure are presented as energy dispersive X-ray analysis, high-resolution transmission electron microscopy and SQUID measurements. The results prove an unexpected very weak ferromagnetism rare earth side.

1. D. Goll H. Kronmüller High-performance permanent Magnets Naturwissenschaften (2000) 87:423*438 2. Karl J. Strnat Modern Permanent Magnets for Applications in Electro-Technology University of Dayton, Ohio Proceedings of the IEEE, Volume 78, Number 6, June 1990

MA 16.65 Tue 10:30 Poster D

Electronic and magnetic properties of Ti_4O_7 and Ti_5O_9 Magnéli phases — Ivetta V. Slipukhina, •Konstantin Z. Rushchanskii, Stefan Blügel, and Marjana Ležaić — Peter Grünberg Institut, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

For several decades binary transition-metal oxides have attracted increasing attention as resistively switching materials. Resistive switching in many of these oxides is claimed to be based on the formation and disruption of highly-conductive filaments, through which the current flow is realized. However, still very little is known about the composition, structure and dimensions of these filaments. Recent low-temperature conductivity and *in situ* current-voltage measurements confirmed that the conducting filaments in $Pt/TiO_2/Pt$ [1], as well as Fe-doped $SrTiO_3$ [2] are composed of Magnéli phases Ti_nO_{2n-1} (mostly n=4 or 5), which are mixed-valence compounds with two Ti^{3+} ($3d^1$ electronic configuration) and $(n-2)$ Ti^{4+} ($3d^0$ configuration) ions.

In this work we aimed to develop a fundamental understanding of the mechanisms that underlie the phase transitions in Magnéli phases like Ti_5O_9 and Ti_4O_7. With this aim we performed DFT calculations in order to illuminate the changes in their electronic structure on a microscopic level and establish relations between the structural, electronic and magnetic properties and their role in phase transitions.

We acknowledge the support by SFB917-Nanoswitches and the Helmholtz Young Investigators Group Programme VH-NG-409.

[1] D.-H. Kwon *et al.*, Nature Nanotech. **5**, 148 (2010).
[2] R. Münstermann *et al.*, Advanced Materials **22**, 4819 (2010).

MA 16.66 Tue 10:30 Poster D

Site occupancy analysis of cobalt in a M-type ferrite hard magnetic material — •Shunsuke Muto, Kazuyoshi Tatsumi, and Kazuma Hattori — Graduate School of Engineering, Nagoya University, Nagoya 464-8603, Japan

High angular resolution electron channeling X-ray spectroscopy (HARECXS), as a useful extension of atom location by channeling enhanced microanalysis (ALCHEMI), has been applied to local structure analysis in crystals with the development of digitally-controlled TEM. In this method, intensities of characteristic X-ray are measured by digitally and continuously changing the incident beam direction. The obtained dataset contains information on e.g. impurity sites and their occupancies in the crystalline material of interest. In this study we applied the method to Sr-M type ferrite (SrFe12O19) having large uniaxial anisotropy (a=0.588 nm, c=2.302 nm), and examined the effect of higher order Laue zones (HOLZ) on the quantitative analysis.

The site occupancy analysis of a magnetic impurity, cobalt in the M-type ferrite, substituting for the five kinds of the Fe sites. HARECXS analyses around two independent zone axes could be very effective to precisely determine the site occupancy of the trace element. We discuss the correlation between the impurity occupation sites and magnetic properties.

MA 16.67 Tue 10:30 Poster D

Magnetic and structural properties of $LiMn_{1-x}Ni_xPO_4$ — •Thomas Kolb[1], Alexander Ottmann[1], Carsten Jähne[1], Hans-Peter Meyer[2] und Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, University of Heidelberg, D-69120 Heidelberg, Germany — [2]Institut für Geowissenschaften, University of Heidelberg, D-69120 Heidelberg, Germany

We present structural and magnetic properties of $LiMn_{1-x}Ni_xPO_4$ with $0 \leq x \leq 0.5$ synthesized by solid state reaction as well as by microwave-assisted hydrothermal synthesis. For both doping series, chemical analysis, i.e. Mn:Ni:P, performed by means of energy-dispersive X-ray analysis confirms that the actual Ni content agrees well to the nominal composition. Powder x-ray diffraction implies single-phase materials with orthorhombic olivine structure ($Pnma$). The evolution of lattice parameters obeys Vegard's law and agrees to the fact that replacing Mn^{2+} by smaller Ni^{2+} corresponds to negative chemical pressure $\Delta V/V \approx -8 \cdot 10^{-4}/\%\text{Ni}$. While the onset of long-range antiferromagnetic order at $T_N = 32\,\text{K}$ does not depend on the Ni-content, there are changes in the magnetic anisotropy.

MA 16.68 Tue 10:30 Poster D

Thermal Expansion and Grüneisen scaling in single-crystalline $LiMn_{1-x}Ni_xPO_4$ — Christopher Dietl[1], •Lars Wallbaum[1], Kunpeng Wang[1], Carsten Jähne[1], Herbert Müller[3], Hans-Peter Meyer[2], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, University of Heidelberg, D-69120 Heidelberg, Germany — [2]Institut für Geowissenschaften, University of Heidelberg, D-69120 Heidelberg, Germany — [3]Institut für Festkörperphysik, Technische Universität Wien, A-1040 Wien, Austria

Li-based olivine phosphates LiMPO4 (M = Mn, Fe, Co, Ni) exhibit an enormous potential for applications. One the one hand, their electrochemical cyclability and high-temperature stability renders them next-generation cathode materials for Li-ion batteries. In addition, they exhibit complex ordering phenomena, large magnetoelectric effects and unusual ferrotoroidic domains which are supposed to be relevant for data storage applications. In order to study the fundamental properties we have grown $LiMn_{1-x}Ni_xPO_4$ single crystals by the travelling-solvent floating-zone method. Thermal expansion studies along the crystallographic axes by means of capacitive dilatometry imply strong magnetic-elastic coupling. The onset of long-range magnetic order is associated with pronounced lambda-like anomalies in the a- and c-axis thermal expansion and the magnetic specific heat. The data show a strong positive hydrostatic pressure dependence of T_N and a large fluctuation regime. The effect of Ni-doping on the magnetic anisotropy as probed by the spin-flop field is discussed.

MA 16.69 Tue 10:30 Poster D

Magnetic and defect-properties of Co implanted TiO_2 — •Oguz Yildirim[1,4], Steffen Cornelius[1,4], Mykola Vinnichenko[1], Maik Buterling[2], Andreas Wagner[2], Alevtina Smekhova[3], and Kay Potzger[1] — [1]Institute of Ion Beam Physics and Materials Research, HZDR, POB 510119, 01314, Dresden, Germany — [2]Institute for Radiation Physics, HZDR, POB510119, 01328, Dresden, Germany — [3]MSU, Faculty of Physics, Solid State Physics and Magnetism Departments,Moscow, Russia — [4]TU Dresden, Helmholtzstr. 10, 01069, Dresden, Germany

The magnetic and structrual properties of the potential diluted magnetic oxide (DMO), i.e. Co implanted TiO_2 thin films have been investigated. These films have been grown by magnetron sputtering on $SrTiO_3$ single crystals. Avoidence of possible magnetic contamination has been verified by magnetometry measurements after substrate preparation and deposition. For magnetic doping, implantations of Co^+ ions have been performed at atomic concentrations of 0.5%, 2.5% and 3% respectively. The dependencies between the fluence implanted, defect creation and ferromagnetic properties have been investigated using magnetometry, positron annihilation spectroscopy and structural characterisation.

This work is supported by the Initiative and Networking Fund of the German Helmholtz Association, Helmholtz-Russia Joint Research Group HRJRG−314, and the Russian Foundation for Basic Research, RFBR $\#12-02-91321-SIG-a$.

MA 16.70 Tue 10:30 Poster D

Coordination-driven magnetic-to-nonmagnetic transition in manganese doped silicon clusters — •Linn Leppert[1], Vicente Zamudio-Bayer[2,3], Konstantin Hirsch[2,3], Andreas Langenberg[2,3], Jochen Rittmann[2,3], Martin Kossick[2,3], Robert Richter[3], Akira Terasaki[4], Thomas Möller[3], Stephan Kümmel[1], Bernd von Issendorff[5], and J. Tobias Lau[2] — [1]Theoretische Physik IV, Universität Bayreuth, 95440 Bayreuth, GER — [2]Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, 12489 Berlin, GER — [3]Institut für Optik und Atomare Physik, Technische Universität Berlin, 10623 Berlin, GER — [4]Cluster Research Laboratory, Toyota Technological Institute, 717-86 Futamata, Ichikawa, Chiba 272-0001, JP — [5]Fakultät für Physik, Universität Freiburg, 79104 Freiburg, GER

X-ray Magnetic Circular Dichroism (XMCD) spectroscopy allows to obtain fundamental insight into magnetic properties of free, size-selected clusters. We demonstrate using a combination of XMCD and non-empirical density functional theory that the magnetic moment of small Si clusters doped with a single Mn impurity is completely quenched as soon as a cluster size of 10 Si atoms is exceeded. This is a result of an abrupt increase of the impurity coordination from 10 to 11 Si atoms. Since the impurity coordination in small exohedrally doped Si clusters is close to that observed in bulk Si, smaller clusters are, contrary to intuition, far better suited for prediciting the magnetic properties of the bulk system than larger endohedrally doped clusters.

MA 16.71 Tue 10:30 Poster D

Pressure induced Ferromagnetism in undoped ZnO pellets — •Chen Yu-Chun[1], Eberhard Goering[1], Zumin Wang[1], Lars Jeurgens[2], Thomas Tietze[1], and Gisela Schütz[1] — [1]Max Planck Institute for Intelligent System, Stuttgart, Germany — [2]Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

Room-temperature ferromagnetism (RTFM) has been found in undoped ZnO thin film1-2 and nanostructures3-4 even though bulk samples exhibit no ferromagnetic ordering. This unexpected phenomenon is still controversial; however, numerous reports have reconfirmed the presence of RTFM in ZnO and excluded unintended contribution from impurities. The origin of RTFM in d0 oxides is not yet fully understood. It is assumed that this amazing property could be ascribed to surface oxygen vacancies2,4. In our study we present that RTFM can be induced in bulk ZnO by pressing pure non-ferromagnetic ZnO nanoparticles into pellets. The possible mechanism behind this finding is short-range interaction between isolated spin moments is achieved after mechanical compression. The RTFM behavior can be further enhanced in post-annealed pellets. XPS analysis suggests that more oxygen-related vacancies created after thermal treatment play a crucial rule in this ferromagnetic behavior. It is also found that a carbon-free surface can facilitate the interaction between isolated spin moments. References 1. N. H. Hong, et al., J. Phys: Condens. Matter. 19, 036219 , 2007 2. P. Zhan, et al., J. Appl. Phys. 111, 033501, 2012 3. S. Banerjee, et al., 182501, 2007 4. J. I. Hong, et al., Nano Lett. 12, 576, 2012

MA 16.72 Tue 10:30 Poster D

Magnetic phases and anisotropy in ion irradiated SiC — •Yutian Wang[1], Lin Li[1], Slawomir Prucnal[1], Zhaorong Yang[2],

Kay Potzger[1], and Shengqiang Zhou[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [2]Key Laboratory of Materials Physics Institute of Solid State Physics, Chinese Academy of Sciences, Hefei 230031, People's Republic of China

SiC, as an important electronic and optoelectronic material, has been found to be ferromagnetic after ion or neutron bombardment. So far the original ferromagnetism is still unknown; however the fact that the intrinsic or artificial defects are closely related to the ferromagnetism is a consensus. We prepare ferromagnetic SiC by Ne ions irradiation. Our results show that the saturation magnetization has increased initially by increasing the irradiation fluence, then dropped to almost zero since a large irradiation fluence induced too much disorder[1]. We observe two coexisting magnetic phases. One is superparamagnetic with a blocking temperature around 50 K, while another one has a Curie temperature well above room temperature. The sample also exhibits magnetic anisotropy with the in-plane as the easy axis. Chemical or physical etchings were preformed to correlate the magnetization to the implantation depth. At last, the FDMNES fitting results of carbon K-edge of SiC XAS (X-ray absorption spectroscopy) also present in this contribution.

Refence: 1.Li, L., et al., Appl. Phys. Lett., 98, 222508 (2011).

MA 16.73 Tue 10:30 Poster D

Kerr- and Faraday microscope for space- and time-resolved studies — •Oliver Schmitt, Daniel Steil, Sabine Alebrand, Mirko Cinchetti, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany

Characterization of the magnetic properties of thin films is extremely important both for fundamental studies as well as for technical applications. We present a multi-purpose magneto-optical microscope[1] for the investigation of structured magnetic thin films. The setup can be used for both static and dynamic (pump-probe) measurements. It is moreover compatible with samples with arbitrary magnetic anisotropy, as it allows Kerr measurements in polar and longitudinal geometry as well as in transmission (Faraday geometry). We demonstrate that the microscope can be used in the following modi: (i) static imaging mode (in polar Kerr and Faraday geometry) with a spatial resolution of 1 micron. (ii) time-resolved mode (polar Kerr geometry) with a temporal resolution of four hundred femtoseconds.

MA 16.74 Tue 10:30 Poster D

Scanning magnetoresistance microscopy as a multifunctional tool — •Dmitriy Mitin[1], Michael Grobis[2], and Manfred Albrecht[1] — [1]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [2]San Jose Research Center, HGST, 3403 Yerba Buena Rd., San Jose, California 95135, USA

Scanning magnetoresistance microscopy (SMRM) is a powerful imaging technique, that uses conventional hard disk drive recording heads as a sensor for raster scanning in physical contact with a magnetic film sample. The modern vintages of MR heads are capable of reaching the resolution down to 15 nm in down-track direction, what is comparable with magnetic force microscopy. The unique ability to apply a localized field up to 1 T to the sample makes this tool attractive for recording experiments on continuous films as well as on nanostructures. Thanks to the high bandwidth of the embedded inductive coil system, ultra short magnetic field pulses in the sub-ns range can be applied. This fact allows using this setup as a research instrument for studying dynamic magnetization reversal processes on the nanoscale.

MA 16.75 Tue 10:30 Poster D

Temperature Dependent High Resolution Imaging of the Domain Structure of LSMO Thin Films via SEMPA — Robert M. Reeve, •Pascal Krautscheid, Markus König, Christian Mix, Michael Foerster, Gerhard Jakob, and Mathias Kläui — Institut für Physik, Johannes Gutenberg-Universität Mainz, 55699 Mainz, Germany

The domain configuration of 50 nm thick $La_{0.7}Sr_{0.3}MnO_3$ films has been directly investigated using scanning electron microscopy with polarization analysis (SEMPA). The films are grown using pulsed laser deposition and then rapidly transferred ex-situ in a protective environment to the analysis chamber to maintain the cleanliness of the surface. Magnetic imaging is subsequently carried out at variable temperatures in our ultra-high vacuum SEMPA chamber, without the requirement for prior treatment of the surface. We are able to demonstrate a spatial resolution of 20 nm for the magnetic images. The large scale domain structure reflects a primarily uniaxial anisotropy in the films, consistent with previous work [APL 99, 062508 (2011)] and ex-situ measurements using the magneto-optic Kerr effect. The temperature dependence of the image contrast is investigated between 30 K and ambient conditions and compared to the behavior of the magnetization curves obtained from superconducting-quantum interference device (SQUID) magnetometry on the same samples. The SEMPA contrast is observed to decrease faster than the magnetization, which can be explained by the mechanism of the generation of spin polarization (double exchange) in this material.

MA 16.76 Tue 10:30 Poster D

Quantitative MFM on a $BaFe_2(As_{0.24}P_{0.76})_2$ single crystal — •Fabian Rhein[1], Silvia Vock[1], Henry Stopfel[1], Ulrike Wolff[1], Volker Neu[1], Dmytro S. Inosov[2], Yong Liu[2], Chengtian Lin[2], Hans J. Hug[3], Niraj Joshi[3], Sevil Özer[3] und Ludwig Schultz[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. BOX 270116, 01171 Dresden, Germany — [2]Max Planck Institute for Solid State Research,Heisenbergstraße 1, 70569 Stuttgart, Germany — [3]Institute of Physics, University Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland

The discovery of iron based superconductors (SC) in 2008, motivated the intensive investigation of characteristic properties of differently doped single crystals. In particular, the analysis of the temperature dependent magnetic penetration depth λ(T) and the properties of the vortex arrangement are important parameters to characterize a SC.
Quantitative magnetic force microscopy (MFM) enables the determination of these quantities. The measured MFM signal is a convolution between the stray field of a magnetic flux line and the magnetization of the tip. To be able to extract λ(T) from the measured data different methods exists. We show, that the commonly used monopole-monopole model[1,2] can be replaced by a more convenient tip calibration procedure[3] and a more realistic description of the magnetic flux line's stray field.
Furthermore we extracted the vortex arrangement by statistical evaluation methods.

MA 16.77 Tue 10:30 Poster D

A next-generation room-temperature AFM setup with optical access for magnetic imaging using a single spin sensor — •Thomas Häberle, Dominik Schmid-Lorch, Friedemann Reinhard, and Jörg Wrachtrup — 3. Physikalisches Institut und Forschungszentrum SCoPE, Universität Stuttgart, Germany

We work on a novel magnetic field sensor that is based on the nitrogen-vacancy (NV)-color center in diamond. The electron spin structure of the NV-center allows us to perform optically detected electron spin resonance (ESR) measurements, which can be made sensitive to the ambient magnetic field. Combined with an AFM, these atomic-sized color centers promise an even higher spatial resolution than the MFM [1] while reducing back-action on the sample to a minimum.

I present first results as well as the methods and instrumental setup used to conduct these measurements. The core component of the setup is a next-generation commercial AFM, featuring additional optical access. This allows readout of the spin state via confocal microscopy with simultaneous imaging and manipulation of the sample on a sub-nanometer scale with the AFM.

Applications of this technique are detection and imaging of single electron spins [2] and small nuclear spin ensembles.

[1]G. Balasubramanian et al., Nature Vol 455, 648-651 (2008)
[2]M.S. Grinolds et al., arXiv:1209.0203v1 [cond-mat.mes-hall] (2012)

MA 16.78 Tue 10:30 Poster D

Laterally resolved thermal imaging using magneto-optical indicator films — •Mikhail Kustov[1], Natalya Mamkina[2], Rostislav Grechishkin[2], and Jeffrey McCord[1] — [1]Nanoscale Magnetic Materials, Magnetic Domains, Institute for Materials Science, University of Kiel, 24143 Kiel, Germany — [2]Laboratory of Magnetoelectronics, Tver State University, 170000 Tver, Russia

A novel approach for imaging of lateral temperature distributions is demonstrated. The method involves an optical polarization microscope and a magneto-optical indicator film (MOIF), which is placed in contact with the investigated sample in the same way as for the imaging of magnetic stray fields [1]. Since the Faraday rotation is a function of the local saturation magnetization of the MOIF sensing layer and the saturation magnetization is a function of temperature, the MOIF can be exploited as a transducer of a local variation of temperature into

a variation of magneto-optical contrast. In order to obtain maximum sensitivity the Curie temperature of the sensing layer is chosen to be close, but still above the temperature range of investigation. MOIFs with both planar and uniaxial magnetic anisotropy can be used.

Relying on optics, the imaging scheme has the potential to work up to high temporal resolution, only depending on thermal conductions. Temperature changes occurring within a few microseconds can be measured with lateral resolution. Temperature resolution of the order of 0.01K (for integral measurements) is demonstrated.

[1] R. Grechishkin et al., in: B. Azzerboni et al. (eds.), Magnetic Nanostructures in Modern Technology, pp.195-224.

MA 16.79 Tue 10:30 Poster D

Study of magnetocaloric properties of Gd_4Mn_8 molecules using the finite-temperature Lanczos method — •Christian Heesing and Jürgen Schnack — Universität Bielefeld, Universitätsstr. 25, D-33615 Bielefeld

The magnetocaloric effect can be used to cool or heat a system by varying the external magnetic field. To optimize this effect one needs magnetic molecules with big entropy changes when sweeping the field isothermally. Those big entropy changes can be found in molecules with a high density of low-lying high spin multiplets. In this contribution we discuss molecules of the Gd_4Mn_8 class [1] that have been studied by the finite-temperature Lanczos method [2] in the Heisenberg-model. This method generates very accurate approximations of thermal observables for Hilbert space dimensions of up to 10^{10}.

[1] T. N. Hooper *et al.*, Angew. Chem. Int. Ed. **51**, 4633 (2012)
[2] J. Schnack, O. Wendland, Eur. Phys. J. B **78** (2010) 535-541

MA 16.80 Tue 10:30 Poster D

The lanthaball molecules {Pr_{13}}, {Nd_{13}}, and {Ce_{13}} - a family of classical Heisenberg systems? — Christian Schröder[1], •Jan Balluff[2], Anthony Chesman[3], Steven Yenias[4], and Marshall Luban[4] — [1]Dept. of Engineering Sciences and Mathematics, Univ. of Applied Sciences Bielefeld, Bielefeld, Germany — [2]Faculty of Physics, Univ. of Bielefeld, Bielefeld, Germany — [3]CSIRO Materials Science and Engineering, Clayton, Victoria, Australia — [4]Ames Laboratory & Dept. of Physics and Astronomy, Iowa State University, USA

The lanthaball molecules {Pr_{13}}, {Nd_{13}}, and {Ce_{13}} are recently synthesized spherical polycarbonatolanthanoid clusters that show interesting magnetic properties. Within each molecule 12 rare-earth ions are located on the vertices of a slightly distorted icosahedron and one spin is placed in the center of the icosahedron. Recent measurements are indicative of intra-molecular antiferromagnetic coupling. However, because of the unquenched orbital momenta of the rare-earth ions one has to take into account spin-orbit-coupling effects which make an exact quantum mechanical treatment of such systems very difficult or even impossible. Here, we report on a classical approach based on a Heisenberg model where the total angular momenta of the rare-earth ions interact via a multiple exchange interaction scenario. We show that our calculations are in good agreement with our experimental data for all three molecules. Furthermore, we discuss extensions of our approach to include spin-orbit-coupling effects.

MA 16.81 Tue 10:30 Poster D

Electronic structure and magnetic properties of a macrocyclic dinickel complex — •Kai Trepte, Claudia Loose, and Jens Kortus — Institut für theoretische Physik

We present first-principle density functional theory (DFT) calculations on an triply bridged dinickel complex[1] including a hexaazadithiophenolate ligand. All DFT calculations are done using the all-electron NRLMOL program package. We focus on the electronic structure close to the Fermi level and calculate the magnetic exchange coupling J using the Heisenberg hamiltonian H=-2J$\vec{S_1}\vec{S_2}$ ($\vec{S_1}$=$\vec{S_2}$=1). We compare our results with known trends within this class of molecules[2].

[1] Inorg. Chim. Acta 362 (2009) 793-798
[2] Coord. Chem. Rev. 253 (2009) 2244 - 2260

MA 16.82 Tue 10:30 Poster D

Finite-temperature Lanczos investigations of anisotropic magnetic ring molecules — •Oliver Wendland and Jürgen Schnack — Bielefeld University, P.O. box 100131, D-33501 Bielefeld

We investigate magnetic properties of even-membered rings built of vanadium(III) with spin $s = 1$. Vanadium(III) ions are known to possess large anisotropies [1]. Thermodynamical observables are obtained by the finite-temperature Lanczos-method (FTLM), which has proven to be rather accurate [2].

[1] I. S. Tidmarsh, L. J. Batchelor, E. Scales, R. H. Laye, L. Sorace, A. Caneschi, J. Schnack and E. J. L. McInnes, Dalton Trans. (2009) 9402-9409
[2] J. Schnack, O. Wendland, Eur. Phys. J. B 78 (2010) 535-541

MA 16.83 Tue 10:30 Poster D

Influence of the gold atom on the magnetic properties of the Ni(II) dinuclear complex — •Jaena Park[1,2], Y. Krupskaya[1], V. Kataev[1], G. Steinfeld[3], N. Beyer[3], J. Lach[3], M. Golecki[3], U. Lehmann[3], M. Gressenbuch[3], B. Kersting[3], B. Büchner[1], and R. Klingeler[2] — [1]IFW Dresden, Germany — [2]University of Heidelberg, Germany — [3]University of Leipzig, Germany

Attaching a magnetic molecular complex to a surface, in particular to a metal surface, is important for molecular spintronics applications. In the present work we study the possibility of attaching a Ni-based dimer complex to a gold surface. We have investigated the influence of an attached gold atom on the magnetic properties of the Ni_2-complex. Here we report two Ni_2-complexes $[Ni_2L(dpbba)]ClO_4(2ClO_4)$ **(1)** and $[Ni_2L(dpbba)Au\,Ph]BPh_4(4BPh_4)$ **(2)** where a gold atom is attached to the phosphorus atom of the head part of **(2)**. Magnetization vs. field $M(H)$ at $T = 1.8\,\mathrm{K}$ and vs. temperature $M(T)$ at $\mu_0 H = 1\,\mathrm{T}$ were measured using a SQUID magnetometer. The analysis of the data using a Heisenberg spin Hamiltonian ($\mathcal{H} = 2JS_1S_2$) reveals that the intramolecular exchange interaction between two core Ni ions is ferromagnetic with $J = -23\,\mathrm{K}$ and $-26\,\mathrm{K}$ for **(1)** and **(2)**, respectively. Our high-field and high-frequency ESR measurements yield a g-factor of 2.17 for both complexes and a negative axial magnetic anisotropy $D = -0.063\,\mathrm{K}$ and $-0.056\,\mathrm{K}$ for **(1)** and **(2)**, respectively, which implies a bistable magnetic ground state in both cases. In conclusion, we observe that the magnetic properties of the Ni_2-complex are not significantly changed by the attachment of the gold atom.

MA 16.84 Tue 10:30 Poster D

Probing the local magnetic properties of $[\mathbf{Mn_6^{III}Cr^{III}}]^{3+}$ deposited on surfaces by SPES and XMCD — •Andreas Helmstedt[1], Aaron Gryzia[1], Niklas Dohmeier[1], Norbert Müller[1], Armin Brechling[1], Ulrich Heinzmann[1], Veronika Hoeke[2], Erich Krickemeyer[2], Thorsten Glaser[2], Mikhail Fonin[3], Samuel Bouvron[3], Philipp Leicht[3], Thomas Tietze[4], Eberhard Goering[4], and Karsten Kuepper[5] — [1]Faculty of Physics, Bielefeld University — [2]Faculty of Chemistry, Bielefeld University — [3]Department of Physics, University of Konstanz — [4]Max-Planck-Institut für Intelligente Systeme, Stuttgart — [5]Department of Physics, University of Osnabrueck

Comprehensive studies of the $[\mathbf{Mn_6^{III}Cr^{III}}]^{3+}$ single-molecule magnet deposited on Au and Si substrates by Spin-Resolved Electron Spectroscopy (SPES) and X-ray Magnetic Circular Dichroism (XMCD) are presented. $[\mathbf{Mn_6^{III}Cr^{III}}]^{3+}$ consists of two bowl-shaped Mn_3-triplesalen units linked by a hexacyanochromate. It exhibits a spin ground state of S_T=21/2. For excitation energies covering the Mn-$L_{2,3}$ region, the spin polarization of Auger electrons originating from the Mn^{III} ions in $[\mathbf{Mn_6^{III}Cr^{III}}]^{3+}$ has been measured at room temperature and without applying external magnetic fields. Radiation damage was monitored by XAS at the Mn-L_3 edge. Corresponding XMCD data have been obtained at 2K and 7T. The local magnetic properties of the Mn constituents in $[\mathbf{Mn_6^{III}Cr^{III}}]^{3+}$ SMM derived from spin polarization data in the paramagnetic phase are compared to results obtained by XMCD. Differences between both methods are discussed.

MA 16.85 Tue 10:30 Poster D

Investigation of $[\mathbf{Fe_6^{III}Cr^{III}}]^{3+}$ Molecules Deposited on Surfaces by XAS, SPES and XMCD — •Niklas Dohmeier[1], Andreas Helmstedt[1], Aaron Gryzia[1], Norbert Müller[1], Armin Brechling[1], Ulrich Heinzmann[1], Veronika Hoeke[2], Erich Krickemeyer[2], Thorsten Glaser[2], and Karsten Küpper[3] — [1]Faculty of Physics, Bielefeld University — [2]Faculty of Chemistry, Bielefeld University — [3]Department of Physics, University of Osnabrueck

$[\mathbf{Fe_6^{III}Cr^{III}}]^{3+}$ is a heptanuclear metal-organic coordination compound containing six Fe^{III} ions and one Cr^{III} embedded in an organic environment. An airbrush-based preparation method leads to large homogeneous samples. X-ray absorption spectroscopy (XAS) was used to monitor the sample oxidation state and its reduction during the performed spin-resolved photoemission measurements (SPES). The spin

polarization of the Auger electrons following the excitation with circularly polarized synchrotron light in the region of the Fe-$L_{2,3}$ absorption edge is measured to reveal information about the magnetic properties of $[\mathbf{Fe_6^{III}Cr^{III}}]^{3+}$. The results were compared to corresponding X-ray magnetic circular dichroism (XMCD) measurements performed at 4 K and 6.9 T. Sum rules are applied to both data sets. SPES and XMCD data for the reference material Fe_2O_3 are presented as well.

MA 17: Magnetic Particles and Clusters (jointly with CPP, BP)

Time: Tuesday 9:30–13:00 Location: H22

Invited Talk MA 17.1 Tue 9:30 H22

Magnetometry to identify the origin of printed documents — •Anna S. Semisalova, Vladimir N. Nikiforov, and Nikolai S. Perov — Lomonosov Moscow State University, Faculty of Physics, Moscow, Russia

Counterfeiting of valuable documents is an increasingly serious problem. For example, diplomas and stock certificates are all the subjects of increasingly frequent and accurate counterfeiting efforts. Identification of the true source of printed documents is a challenging task [1]. Many methods such as chemical analysis, various types of spectroscopy and microscopy, require a special sample preparation which may lead to the destruction of parts of the documents. Magnetometry may provide a non-destructive technique to uniquely identify the source of documents printed by using inks or toners containing magnetic particles.

Here, we will present an overview of the magnetic properties of documents produced by different laser printers (Canon, HP, Lexmark, Kyocera). The magnetic behavior of laser printers toners were investigated by vibrating sample magnetometry. Magnetic parameters such as coercive field and magnetic moment were measured, compared and are shown to be a possible source for classification, differentiation and identification of toner powders. The investigation of magnetic properties of toners could be considered as a new surprisingly simple non-destructive approach to certify and identify certain printers, since the printer toners were found to vary with manufacturer. The practical applications for counterfeit analysis are discussed. 1. Scientific Examination of Questioned Documents, ed. by Kelly J.S., 2006.

15 min. break

MA 17.2 Tue 10:15 H22

Printable giant magnetoresistive devices — •Daniil Karnaushenko[1,2], Denys Makarov[1], Chenglin Yan[1], Robert Streubel[1,2], and Oliver G. Schmidt[1,2] — [1]Institute for Integrative Nanosciences IFW Dresden, Helmholtzstraße 20, Dresden, 01069 Germany — [2]Material Systems for Nanoelectronics Chemnitz University of Technology, Straße der Nationen 62, Chemnitz, 09107 Germany

The rise of printable electronics is mainly indebted to huge efforts in materials science to fabricate cost-efficient versatile electronic building blocks such as transistors, diodes and resistors. However, the fabrication of printable electronic sensors and contactless switches operating in combination with magnetic fields remains challenging, mainly due to the lack of appropriate sensing compounds at ambient conditions. The printable magnetic sensor would act as a contactless switch in a complex printed electronic circuit. For this purpose, magnetic sensors with high sensitivity operating at room temperature have to be developed as inks, pastes or paints. Here, we demonstrate the first printable magnetic sensor that relies on the GMR effect. The developed multicomponent magnetic ink containing GMR flakes and nonconductive binder can be easily applied on various substrates, such as paper, polymer and ceramic. The fabricated sensor exhibits a room-temperature GMR of up to 8%, which is sufficiently high to develop a complete printed electronic circuit that is able to respond to an external magnetic field, opening new application fields in the modern electronics.

MA 17.3 Tue 10:30 H22

Influence of the local atomic structure on the magnetic properties of particulate FePt-X films — •S. Wicht[1,2], V. Neu[1], L. Schultz[1,2], O. Mosendz[3], G. Parker[3], D. Weller[3], and B. Rellinghaus[1] — [1]IFW Dresden, P.O. Box 260116, D-01171 Dresden, Germany. — [2]TU Dresden, IFWW, D-01062 Dresden, Germany. — [3]HGST, 3403 Yerba Buena Rd, San Jose, CA-95135, USA.

FePt-nanoparticles are a promising materials candidate for recording media aiming at storage densities beyond 1 Tbit/in^2. High-resolution electron microscopy (HRTEM) and vibrating sample magnetometry (VSM) are used to correlate the structural and magnetic properties of highly textured particulate films of matrix-isolated $L1_0$ ordered FePt-X (X: Cu/Ag). Particle size distributions and orientations of the particles' magnetic easy axes with respect to their MgO seed crystals and the substrate plane are determined from planview and cross-sectional HRTEM. The texture spread of the [001] easy axes is found to be roughly 3^o and clearly larger than the misalignment of the MgO crystals. Atomically resolved characterization of the FePt-X/MgO interfaces shows that this discrepancy is due to the nucleation of the FePt-X growth at MgO step edges. In accordance with the structural data, remanence measurements reveal only a weak dipolar coupling among the spatially separated FePt-X nanomagnets, and the anisotropy fields of the films are $\mu_0 H_A = 8 - 9T$. Surprisingly, the *magnetic* texture width as determined from an analysis of the hard axis magnetization curves is found to be one order of magnitude larger than the texture spread of the [001] axes. Possible origins of this finding are discussed.

MA 17.4 Tue 10:45 H22

Structural and Magnetic Properties of FePt@MnO Heterodimer Nanoparticles — •Alice Klapper[1], Xiao Sun[1], Oleg Petracic[1], Ulrich Rücker[1], Oskar Köhler[2], Heiko Bauer[2], Wolfgang Tremel[2], and Thomas Brückel[1] — [1]JCNS-2 and PGI-4, Forschungszentrum Jülich GmbH — [2]Institute of Inorganic Chemistry and Analytical Chemistry, Johannes Gutenberg University Mainz

On the length scale of few nanometers, surface effects are not negligible and therefore play an important role for the magnetic behavior of nanoparticles. In this work we investigate the magnetic properties of so-called FePt@MnO heterodimer nanoparticles, which consist of two exchange-coupled spherical nanoparticles, i.e. a ferromagnetic FePt and an antiferromagnetic MnO particle. The dimer nanoparticles have been precharacterized with respect to their structural properties via small angle x-ray scattering (SAXS) and a form factor model for particles consisting of two spherical subunits could be verified. This model has been proven by the anomalous SAXS (ASAXS) technique. The magnetic properties dependent on the size of the nanoparticles have been investigated with ZFC and FC measurements, using SQUID magnetometry. The exchange coupling could be proven by an exchange bias in hysteresis measurements as function of temperature. To investigate the ordering phenomenon the samples under study have been deposited on silicon substrates and dried with different applied magnetic fields. The dried samples have been studied using SEM and a chiral ordering of the heterodimer nanoparticles has been observed.

MA 17.5 Tue 11:00 H22

Stability and Meta-stability of Clusters in a Reactive Atmosphere: Theoretical Evidence for Unexpected Stoichiometries of Mg_MO_x — •Saswata Bhattacharya, Sergey V. Levchenko, Luca M. Ghiringhelli, and Matthias Scheffler — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin-Dahlem 14195, Germany

Applying genetic algorithm and replica exchange molecular dynamics in a cascade approach we calculate structure and composition of Mg_MO_x clusters at realistic temperatures and oxygen pressures. The cascade starts with force field and goes up to density functional theory with exact exchange plus correlation in the random phase approximation.[1] The stable compositions are identified using *ab initio* atomistic thermodynamics. We find that at realistic environmental conditions small clusters (M = 1-5) are in thermodynamic equilibrium when $x > M$. Non-stoichiometric clusters are found to have in general higher spin multiplicity than stoichiometric ones. This suggests a possibility of tuning magnetic properties by changing environmental conditions.

We appreciate support from the cluster of excellence UniCat financed by the German Science Foundation (DFG).

[1] X. Ren, P. Rinke, C. Joas, and M. Scheffler, Invited Review: Random-phase approximation and its applications in computational chemistry and materials science. J. Mater. Sci. 47, 21 (2012).

MA 17.6 Tue 11:15 H22

Cycloidal spin-structures in Bismuth iron-oxide nanoparticles — •Joachim Landers[1], Soma Salamon[1], Werner Keune[1], Marianela Escobar[2], Doru Lupascu[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, Duisburg, Germany — [2]Institute for Materials Science, University of Duisburg-Essen, Essen, Germany

Bismuth iron-oxide ($BiFeO_3$, BFO) nanoparticles of various diameters d prepared by a wet chemical method were studied using Mössbauer spectroscopy to determine the influence of the particle size ($d \gtrapprox 50$nm) on the cycloidal spin structure observable in BFO bulk material. Mössbauer spectra were measured at several temperatures to determine the orientation of magnetic moments relative to the crystal axes. This can be analyzed by investigating the quadrupole level shift, which was in good agreement to bulk references. Considering effects on the relative spectral intensities and the resulting effective (hyperfine) magnetic field, a model of the ideal cycloidal structure was used to simulate a theoretical spectrum consistent with experimental Mössbauer spectra measured at 4.2K in an applied magnetic field of about 5T. The combination of both methods verifies the presence of a 'bulk-like' spin structure, which is still stable in nanoparticles with a diameter of about 54nm.

15 min. break

MA 17.7 Tue 11:45 H22

Ab initio spin-dynamics for nanostructures with application to domain walls through a Co nanocontact — Laszlo Balogh[1], Laszlo Udvardi[1], Krisztian Palotas[1], •Laszlo Szunyogh[1], and Ulrich Nowak[2] — [1]Department of Theoretical Physics and Condensed Matter Research Group of the Hungarian Academy of Sciences, Budapest University of Technology and Economics, H-1111 Budapest, Hungary — [2]Department of Physics, University of Konstanz, 78457 Konstanz, Germany

To calculate the magnetic ground state of nanoparticles we present a self-consistent first-principles method in terms of a fully relativistic embedded cluster multiple scattering Greens function technique. Based on the derivatives of the band energy, a Newton-Raphson algorithm is used to find the ground-state configuration. An extension of the method to finite temperatures is also presented.

The method is applied to a cobalt nanocontact that turned out to show a cycloidal domain wall configuration between oppositely magnetized leads. We found that a wall of cycloidal spin structure is about 30 meV lower in energy than the one of helical spin structure. A detailed analysis revealed that the uniaxial on-site anisotropy of the central atom is mainly responsible to this energy difference. The huge uniaxial anisotropy energy is accompanied by an enhancement and anisotropy of the orbital magnetic moment of the central atom. By varying the magnetic orientation at the central atom, we identify various on-site anisotropy terms and also those due to higher order spin interactions.

MA 17.8 Tue 12:00 H22

The Anderson Impurity Model in Finite Systems: A Study of Chromium Impurities in Gold Clusters — •Konstantin Hirsch[1,2], Vicente Zamudio-Bayer[1,2], Andreas Langenberg[1,2], Markus Niemeyer[1,2], Bruno Langbehn[1,2], Thonmas Möller[1], Akira Terasaki[3,4], Bernd von Issendorff[5], and Julian Tobias Lau[2] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin — [2]Institut für Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH — [3]Cluster Research Laboratory, Toyota Technological Institute, 717-86 Futamata, Ichikawa, Chiba 272-0001, Japan — [4]Department of Chemistry, Kyushu University, 6-10-1 Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan — [5]Fakultät für Physik, Universität Freiburg

A long standing problem in condensed matter physics is the interaction of a single magnetic impurity with a free electron gas resulting in interesting phenomena like the Kondo effect. In recent years substantial progress was obtained by studying atomic scale systems. Here we want to follow this approach and investigate the interaction of a single magnetic impurity with a finite free electron gas. $CrAu_n^+$ clusters serve as a model system. We can show that the size dependence of the local spin magnetic moment of $CrAu_n^+$ can well be described within in the Anderson impurity model, whereas the interaction of the localized impurity states with the electron bath of the gold matrix is governed by quantum confinement in the host, which is abscent in the corresponding bulk material.

MA 17.9 Tue 12:15 H22

Rotational dynamics of Ni nanorod colloids characterized by optical transmission and neutron scattering — •Philipp Bender[1], Albrecht Wiedenmann[2], Annegret Günther[3], Dirk Honecker[3], Andreas Tschöpe[1], and Rainer Birringer[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Institut Laue Langevin, Grenoble, France — [3]University of Luxembourg, Luxembourg

With diameters below 42 nm, Ni nanorods are uniaxial ferromagnetic single-domain particles. When dispersed in a liquid matrix, alignment of their magnetic moments along an external magnetic field is achieved by a rotation of the entire particle. In time-modulated magnetic fields the switching dynamics depends on the viscous friction of the nanorods in the liquid matrix. Due to the anisotropic electrical polarizability optical transmission measurements can be used to detect the response of a colloidal dispersion of Ni nanorods to a rotating magnetic field. In particular, the rotational diffusion coefficient can be extracted from the phase shift between the periodic variation of the rotating magnetic field and the resulting oscillation in the optical transmission. In the present study Small Angle Neutron Scattering (SANS) is used in addition to the transmission of polarized light to experimentally determine the hydrodynamic interactions of Ni nanorods with the liquid matrix in a rotating magnetic field.

MA 17.10 Tue 12:30 H22

Magnetic correlations in 3D ordered nanoparticle assemblies — •Elisabeth Josten[1], Oleg Petracic[1], Ulrich Rücker[1], Artur Glavic[2], Valeria Lauter[2], Erik Wetterskog[3], German Salazar-Alvarez[3], Lennart Bergström[3], and Thomas Brückel[1] — [1]JCNS-2 and PGI-4, Forschungszentrum Jülich, Germany — [2]Oak Ridge Natl Lab, Quant. Cond. Mat. Div, Oak Ridge, TN 37831 USA — [3]Stockholm Universitet, Department of Materials and Environmental Chemistry, Stockholm, Sweden

Nanoparticle superlattices can be considered as novel type of materials with controllable electronic, optical and magnetic properties. Understanding the magnetic behavior of ordered nanoparticle arrays is an important step towards the controlled design of e.g. novel devices. We have studied γ-Fe2O3 nanocubes and nanospheres with a diameter ≈ 10 nm. The particles have been deposited on a Si substrate to form highly ordered superstructures (mesocrystals) using a drop casting method. Structural characterization has been carried out using SEM, AFM, TEM and GISAXS. Depending on the shape of the particles, the arrays show mesostructures with bct or fcc symmetry with relatively long structural correlation lengths of 2-10 μm. In order to investigate magnetic inter-particle correlations we have employed grazing incidence neutron scattering experiments in reflectometry mode at the JCNS-instrument TREFF at the FRM II in Garching and in GISANS mode at the Magnetism Reflectometer at the SNS in Oak Ridge. These experiments yielded the degree of magnetic correlation for the in-plane and out-of-plane directions at different applied fields.

MA 17.11 Tue 12:45 H22

***Ab initio* study of spin and charge dynamics on the homodinuclear complex $[Ni_2^{II}(L\text{-}N_4Me_2)(emb)]$** — •Wei Jin, Georgios Lefkidis, and Wolfgang Hübner — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Box 3049, 67653 Kaiserslautern, Germany

We present a first-principles investigation of spin and charge dynamics on the recently synthesized and characterized homodinuclear compound $[Ni_2^{II}(L\text{-}N_4Me_2)(emb)]$ [1,2]. By calculating the oscillator strengths of the optical transitions we find good agreement of the peak positions in our theoretical ground-state absorption spectra with experiment. Extending our previous work [1], we predict a *local* ultrafast spin-flip scenario induced by high-energy laser pulses with the participation of charge-transfer states that are identified by Mulliken analysis of the involved states.

Additionally, for the two transient electronic states observed spectroscopically, which are related to the two charge dynamics with different time scales, we also fully characterize them and identify their relaxation time differences by exploiting the selection rules. The proof-of-principle demonstration clearly shows the possible application of optical properties and paves the way to coherently manipulate and detect spin and charge dynamics on dinuclear or even on multinuclear complexes.

[1] G. Lefkidis *et al.*, J. Phys. Chem. A. **115**, 1774 (2011).
[2] W. Jin *et al.*, Phys. Rev. Lett., in press.

MA 18: Topological Defects in Magnetic Materials: from Devices to Cosmos (PhD-Student Symposium jointly with jDPG)

Organizers: Sinéad Griffin, Krzysztof Dymkowski, Yaël Birenbaum (ETH Zurich)

No longer a mathematical curiosity, the number of condensed-matter systems exhibiting topological defects is ever increasing. In particular, recently-discovered topological magnetic materials provide an ideal test-bed for understanding the properties and behaviour of these defects. Among these are skyrmions; a magnetic configuration that, like a Mobius strip, contains a twist that cannot be removed. To date skyrmions have been observed in both magnetic and multiferroic systems. In the field of multiferroics, recently discovered vortices in the hexagonal-manganite family have been shown to be topologically protected, and obey the same scaling laws as expected by the formation of topological defects in the early universe. The direct imaging of such defects is enabled by their property of multiferroism - they ferroelectric order is used to visualise the polar domains and defects which then sets the resulting magnetic order. The proposal and discovery of "magnetic monopoles" in spin-ice provides an interesting analog to the magnetic monopoles first proposed by Dirac. These bundles of magnetism, acting like isolated magnetic charges, were subsequently observed in pyrochlore lattices. Not only is the observation and study of these mathematical objects illuminating, it may also have practical application in the field of quantum computation due to their 'topological' robustness. The organizers thank MaNEP for the generous financial support of the symposium.

Time: Tuesday 9:30–13:45 Location: H16

Invited Talk MA 18.1 Tue 9:30 H16

Skyrmions in magnets — •Maxim Mostovoy — Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

Skyrmions form an important class of topological defects in uniformly ordered states. They emerge in a variety of different physical contexts and have rather unusual properties directly related to their non-trivial topology. First introduced by T. H. R. Skyrme in his unified theory of baryons and mesons, Skyrmions have made their way into condensed matter physics, e.g. as excitations in Quantum Hall ferromagnets and Bose-Einstein condensates. They have been recently observed in a number of helicoidal magnets with non-centrosymmetric crystal lattices, where they play the role of quantized fluxes of effective magnetic field acting on spin-polarized electrons. I will discuss phenomenological description of Skyrmions, microscopic mechanisms for their stabilization in magnetic materials and effects of the coupled dynamics of spins and charges at these topological objects.

Invited Talk MA 18.2 Tue 10:00 H16

Experimental studies of skyrmions in chiral magnets — •Christian Pfleiderer — Physik Department E21, Technische Universität München, D-85748 Garching, Germany

Present day limitations of information technology involving magnetic materials may be traced to the notion that all magnetic materials known until recently represent topologically trivial forms of long-range magnetic order. Recently the first example of a new form of magnetic order has been discovered, which is composed of topologically stable spin solitons driven by chiral spin interactions – so called skyrmions. The skyrmions known to date display several exceptional properties: a topological winding number of -1 implying great stability, very efficient coupling to the conduction electrons in metallic systems by virtue of Berry phases, very weak pinning by defects and magnetic anisotropies, all paving the way to spin torque effects at ultra-low current densities. I will review the current status of the research on skyrmions and related topological solitons in bulk compounds and thin films, focussing on similarities and analogies with conventional magnetic materials.

MA 18.3 Tue 10:30 H16

Rotating skyrmion lattices by spin torques and field or temperature gradients — •Karin Everschor-Sitte[1,2], Markus Garst[2], Benedikt Binz[2], Florian Jonietz[1], Sebastian Mühlbauer[3], Christian Pfleiderer[1], and Achim Rosch[2] — [1]Physik-Department E21, Technische Universität München — [2]Institut für Theoretische Physik, Universität zu Köln — [3]Forschungsneutronenquelle Heinz Maier Leibnitz (FRM II), Technische Universität München

Chiral magnets like MnSi form lattices of skyrmions, i.e., magnetic whirls, which react sensitively to small electric currents j above a critical current density j_c. The interplay of these currents with tiny gradients of either the magnetic field or the temperature can induce a rotation of the magnetic pattern for $j > j_c$. Either a rotation by a finite angle of up to 15° or – for larger gradients – a continuous rotation with a finite angular velocity is induced. We use Landau-Lifshitz-Gilbert equations extended by extra damping terms in combination with a phenomenological treatment of pinning forces to develop a theory of the relevant rotational torques [1]. Experimental neutron scattering data on the angular distribution of skyrmion lattices suggest that continuously rotating domains are easy to obtain in the presence of remarkably small currents and temperature gradients.

[1] K. Everschor *et al.*, PRB **86**, 054432 (2012)

MA 18.4 Tue 10:45 H16

Giant generic topological Hall resistivity of MnSi under pressure — •Robert Ritz[1], Marco Halder[1], Christian Franz[1], Andreas Bauer[1], Michael Wagner[1], Robert Bamler[2], Achim Rosch[2], and Christian Pfleiderer[1] — [1]Physik-Department E21, Technische Universität München — [2]Institut für Theoretische Physik, Universität zu Köln

We report detailed low temperature magneto-transport and magnetization measurements in MnSi under pressures up to ~ 12 kbar. Tracking the role of sample quality, pressure transmitter, and field and temperature history allows us to link the emergence of a giant topological Hall resistivity $\sim 50\,\mathrm{n\Omega cm}$ to the skyrmion lattice phase at ambient pressure. We show that the remarkably large size of the topological Hall resistivity in the zero temperature limit must be generic. We discuss various mechanisms which can lead to the much smaller signal at elevated temperatures observed at ambient pressure.

15 min. break

Topical Talk MA 18.5 Tue 11:15 H16

Topological Defects and Quantum Computing — •Simon Trebst — University of Cologne

Topological defects are not only entities of fundamental theoretical beauty, they have also become highly sought-after objects in table-top condensed matter experiments around the world. Part of their attraction comes from their possibly far-reaching relevance as the elementary building blocks in a topological quantum computer. In this talk, I will introduce the main conceptual ideas underlying these computing proposals and discuss beyond the current experimental status of identifying non-Abelian topological defects a number of possible obstacles that will need to be overcome on the way to build the first topological quantum computer.

Topical Talk MA 18.6 Tue 11:45 H16

Cosmic strings in multiferroics — •Nicola Spaldin — ETH Zurich, Switzerland

A key open question in cosmology is whether the vacuum contains topological defects such as cosmic strings, believed to have formed as a result of symmetry-lowering phase transitions in the early universe. An

inexpensive, laboratory-based route to shedding light on the answer is to test the predicted scaling laws for topological defect formation (the so-called Kibble-Zurek mechanism) in condensed matter systems. Here we show that the multiferroic hexagonal manganite oxides – with their coexisting magnetic, ferroelectric and antiphase orderings – have an appropriate symmetry-lowering phase transition for testing the Kibble-Zurek scenario. We present an analysis of the Kibble-Zurek theory of topological defect formation applied to the hexagonal magnanites, show that the recently observed domain vortex cores are formally topologically protected, and that recent literature data are quantitatively consistent with our predictions from first-principles electronic structure theory. Finally, we explore experimentally for the first time to our knowledge the cross-over out of the Kibble-Zurek regime and find a surprising "anti-Kibble-Zurek" behavior.

MA 18.7 Tue 12:15 H16

Ferroelectric Vortices in Hexagonal $YMnO_3$ — •Martin Lilienblum — Department of Materials, ETH Zurich

Hexagonal rare earth manganites $RMnO_3$ (R= Sc, Y, Dy-Lu) exhibit an intriguing domain structure with kaleidoscopic intersections of always six individual domains. These ferroelectric vortices can be seen as topological defects that forms while cooling across the ferroelectric phase transition. Topological defect formation is of general interest since, for example, topological defects may have played an important role during the evolution of the early universe. Here we present an experimental study on the stability of the ferroelectric vortices in flux grown $YMnO_3$ single crystals in annealing experiments up to the phase transition temperature of around 1300 K. In a second experiment we studied the dependence of the density of ferroelectric vortices on the cooling rate. In order to ensure the visualization of the true bulk domain structure we performed an elaborate sample processing by annealing, polishing and piezoresponse force microscopy. In a third experiment we studied the progression of the ferroelectric order parameter below the phase transition by optical second harmonic generation.

15 min. break

Topical Talk MA 18.8 Tue 12:45 H16

Topological physics: from quantum Hall Skyrmions to optical Chern lattices — •Roderich Moessner — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

Topological physics as we understand it today started 30 years ago with the experimental discovery of the quantum Hall effects. Here, we discuss the physics of Skyrmions, spin textures in quantum Hall states exhibiting both conventional and topological forms of order in a delicately intertwined way: they combine, in a physically transparent way, fundamental concepts such as topological stability and Berry phase physics. We provide a detailed analysis of Skyrmion lattices for multicomponent quantum Hall systems, such as (bi)layer graphene or multi-valley semiconductors in a magnetic field. We also point out how these results can be used to inspire a robust design strategy for optical topological band structures for use in cold atomic systems.

Topical Talk MA 18.9 Tue 13:15 H16

Magnetricity and Magnetic Monopoles in Spin ice — •Steve Bramwell — University College London

The analogy between spin configurations in spin ice materials like Ho2Ti2O7 and proton configurations in water ice, H2O, has been appreciated for many years (see Ref. [1] for a review). However it is only in the last few years that this equivalence has been extended into the realm of electrodynamics [2,3]. In this talk I shall describe our recent experimental work that identifies emergent magnetic charges ("monopoles"), transient magnetic currents ("magnetricity") and the universal properties expected of an ideal magnetic Coulomb gas (magnetic electrolyte - "magnetolyte"). These universal properties include the Onsager-Wien effect, "corresponding states" behaviour, Debye-Huckel screening and Bjerrum pairing [4-6]. I will describe experimental results for both traditional spin ice materials (Ho2Ti2O7, Dy2Ti2O7) and a recently discovered system (Dy2Ge2O7).

References:

[1] Bramwell and Gingras, Science, 294 1495 2001 [2] Castelnovo, Moessner & Sondhi, Nature 451 42 (2008) [3] Ryzhkin, JETP 101 481 (2005); [4] Bramwell et al. Nature 461 956 (2009) [5] Fennell et al., & Bramwell Science 326 415 (2009) [6] Giblin, Bramwell et al., Nature Physics 7 252 (2011) [7] Zhou, Bramwell et al., Nat Comm. 478, 1483 (2011)

MA 19: Surface and Interface Magnetism I (jointly with O)

Time: Tuesday 10:30–13:15 Location: H33

MA 19.1 Tue 10:30 H33

Magnetism of Fe on Pt(111) Revisited by Inelastic Scanning Tunneling Spectroscopy — Tobias Schlenk, Alexander Ako Khajetoorians, •Jens Wiebe, and Roland Wiesendanger — Institute of Applied Physics, Hamburg University, Germany

We revisited the magnetism of single Fe atoms [1] and Fe-H_n complexes adsorbed on the surface of Pt(111) by means of magnetic field dependent inelastic scanning tunneling spectroscopy [2,3]. We found that the magnetic easy axis is either perpendicular to or within the surface plane, depending on an fcc or hcp adsorption site. Adsorption of H atoms changes the strength of the magnetic anisotropy and leads to Kondo screening for one of the two Fe-H_2 complexes. For all investigated cases, the magnetic anisotropy energy is almost an order of magnitude lower than recently reported [1].

[1] T. Balashov *et al.*, Phys. Rev. Lett. **102**, 257203 (2009).

[2] A. A. Khajetoorians, S. Lounis, B. Chilian, A. T. Costa, L. Zhou, D. L. Mills, J. Wiebe, and R. Wiesendanger, Phys. Rev. Lett. **106**, 037205 (2011).

[3] B. Chilian, A. A. Khajetoorians, S. Lounis, A. T. Costa, D. L. Mills, J. Wiebe, and R. Wiesendanger, Phys. Rev. B **84**, 212401 (2011).

MA 19.2 Tue 10:45 H33

Structure Driven Complex Magnetic Ordering of a CoO Overlayer on Ir(100) — •Florian Mittendorfer[1], Josef Redinger[1], Raimund Podloucky[2], and Michael Weinert[3] — [1]Inst. of Applied Physics, TU Vienna — [2]Inst. of Physical Chemistry, Univ. Vienna — [3]Univ. Wisconsin-Milwaukee

The adsorption of a mono-layer thick magnetic oxide film on an unmagnetic substrate offers a playground to study the relation between the geometrical structure and the magnetic properties of the film.

I will present our recent results on the magnetic ordering in the ultrathin hexagonal c(10x2) CoO(111) film supported on Ir(100) [1], obtained on the basis of ab initio calculations with the Vienna Ab-initio Simulations Package (VASP). We find a close relationship between the local structural properties of the oxide film and the induced magnetic order, leading to alternating ferromagnetically and antiferromagnetically ordered segments. While the local magnetic order is directly related to the geometric position of the Co atoms, the mismatch between the CoO film and the Ir substrate leads to a complex long-range order of the oxide.

[1] Phys. Rev. Lett. 109 (2012) 015501.

MA 19.3 Tue 11:00 H33

Detecting and Interpreting Spin-Dependent Dissipation Observed with Magnetic Exchange Force Microscopy and Spectroscopy — •Alexander Schwarz, Rene Schmidt, Elena Y. Vedmedenko, and Roland Wiesendanger — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

Magnetic exchange force microscopy (MExFM) and spectroscopy (MExFS) can resolve magnetic surfaces and probe the distance dependence of the magnetic exchange interaction with atomic resolution [1,2]. In both cases the frequency shift of an oscillating cantilever due to conservative tip-sample interactions is detected. By recording the amplitude and the excitation amplitude required to keep the amplitude of the cantilever oscillation constant, the energy loss due to dissipative processes can be determined. It turns out, that this signal can be spin-dependent as well [2,3]. The possible origin of this signal will be discussed in terms of spin-excitations [4] and spin-dependent adhesion-hysteresis [3]. Additionally, it will be shown how the dissipation signal can be used to characterize the tip, which is very important to correctly evaluate force spectroscopy data quantitatively.

[1] U. Kaiser, A. Schwarz and R. Wiesendanger, Nature 446, 522 (2007).
[2] R. Schmidt, A. Schwarz, and R. Wiesendanger, Phys. Rev. Lett. 106, 257202 (2011).
[3] E. Y. Vedmedenko et al., Phys. Rev. B 85, 174410 (2012).
[4] F. Pellegrini, G. E. Santoro, and E. Tosatti, Phys. Rev. Lett. 105, 146103 (2010).

MA 19.4 Tue 11:15 H33

Zeeman splitting in superconducting scanning tunneling microscopy tips — •Matthias Eltschka[1], Berthold Jäck[1], Maximilian Assig[1], Markus Etzkorn[1], Christian R. Ast[1], and Klaus Kern[1,2] — [1]Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany — [2]Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

Scanning tunneling microscopy (STM) is a powerful technique to investigate a manifold of physical and chemical phenomena at the atomic scale. For spin-dependent tunneling, superconducting STM tips are of particular interest due to the well-known spin-polarization of almost 100%, especially in combination with high energy resolution at ultra-low temperatures.

We present STM experiments on a V(100) sample in combination with several V-tips at milli-Kelvin temperatures. The applied magnetic fields exceed the critical magnetic field of bulk V, so that the sample is in the normal conducting state. Due to its reduced dimensions the tip apex remains superconducting in fields up to 10 H_c (bulk). Our evaluation of the experimental data is based on Maki's model taking into account effects of orbital depairing and spin orbit coupling [1, 2]. Zeeman splitting of the superconducting quasi-particle densities of states is observed on several V-tips. Further, the quenching process of the superconducting gaps of the V-tips is investigated as function of magnetic fields.

[1] K. Maki, Prog. Theor. Phys. 32, 29 (1964)
[2] R. Meservey et al., Phys. Rev. B 11 4224 (1975)

MA 19.5 Tue 11:30 H33

Wave function imaging of transition metal impurities near the H/Si(111) surface — •Benjamin Geisler and Peter Kratzer — Fakultät für Physik and Center for Nanointegration, Universität Duisburg-Essen, 47048 Duisburg, Germany

Despite the difficulties encountered in fabricating magnetic semiconductors, doping of silicon by 3d transition metals is an interesting topic in the field of spintronics. Imaging of electronic states on the atomic scale is possible with state-of-the-art scanning tunneling microscopy (e.g., Jancu *et al.*, PRL 2008, for Mn:GaAs) and can improve the understanding of impurity-host and impurity-impurity interactions.

Here we present an *ab initio* viewpoint on Cr, Mn and Fe impurities near the H/Si(111) surface, which has the specialty of providing a similar chemical environment as bulk Si does, while keeping the impurities accessible to surface analysis techniques. According to our calculations, subsurface doping through the H layer is possible. We discuss magnetic and energetic characteristics of isolated impurities and their detection with (magnetic) scanning tunneling microscopy, which is able to discriminate between interstitial and substitutional defects of different depth. Furthermore, delta layers and 2D clusters of interstitial impurities and their magnetic properties are shown. We find that the impurity wave functions are less extended than those of Mn in GaAs, which makes it harder to get ferromagnetic coupling in Si.

MA 19.6 Tue 11:45 H33

First-principles investigation of self energies and theoretical magnetic excitation spectra — •Benedikt Schweflinghaus[1], Manuel Dos Santos Dias[1], Antonio Costa[2], and Samir Lounis[1] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany — [2]Instituto de Física, Universidade Federal Fluminense, 24210-340 Niteroi, Rio de Janeiro, Brazil

Access to magnetic excitation spectra of single atoms deposited on surfaces is nowadays possible by means of low-temperature inelastic scanning tunneling spectroscopy, see e.g. [1]. A theoretical description of these spectra is accessible through the self energy which describes the coupling of the tunnelling electrons and the spin excitation within the adsorbate. We compute this quantity from first-principles utilizing the Korringa-Kohn-Rostoker Green function method combined with time-dependent density functional theory.

We will present results obtained for single 3d transition-metal adatoms placed on Cu(111) as well as on Pt(111) and proceed to a comparison with available experimental data. In particular, we will show how the imaginary part of the self energy, which essentially describes the lifetime of the excitation, is related to the local density of states as well as to the local dynamical magnetic susceptibility.

This work is supported by the HGF-YIG Programme (VH-NG-717 Funsilab).

[1] A. A. Khajetoorians et al., Phys. Rev. Lett. 106, 037205 (2011)

MA 19.7 Tue 12:00 H33

Anisotropic charge oscillations induced by non-magnetic impurities on Fe/W(001) — •Mohammed Bouhassoune, Bernd Zimmermann, Phivos Mavropoulos, Daniel Wortmann, Peter H. Dederichs, Stefan Blügel, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

It has been shown recently that impurities embedded in the surface of few monolayers of Fe deposited on W(001) can trigger intriguing anisotropic charge oscillations [1]. This behavior exhibits a strong dependence on the thickness of the Fe film. Combining first-principles methods: the full-potential linearized augmented plane waves method [2] and the full-potential Korringa-Kohn-Rostoker Green function method [2], we investigate this peculiar behavior by considering single oxygen impurities and find that the anisotropic focused charge oscillations are substantially spin-dependent and are only present when the thickness of the Fe film equals 3 monolayers. We relate this effect to spin-dependent features of the two-dimensional Fermi contours that are crucially affected by the thickness of Fe films.

This work is supported by the HGF-YIG Programme FunSiLab –Functional Nanoscale Structure Probe and Simulation Laboratory (VH-NG-717).

[1] K. Von Bergmann, PhD Thesis, University of Hamburg (2004)
[2] www.juDFT.de

MA 19.8 Tue 12:15 H33

Tunable Kondo resonance of Co atoms on Ag(111) — •María moro[1,2], david serrate[1,2], marten piantek[3], josé ignacio pascual[4], and manuel ricardo ibarra[1,2] — [1]Instituto de Nanociencia de Aragón and Laboratory for Advanced Microscopy, University of Zaragoza, Spain — [2]Dpto. Física de Materia Condensada, University of Zaragoza, Spain — [3]Instituto de Ciencias de Materiales de Aragón (ICMA), Spain — [4]Nanoscience Cooperative Research Center (CIC Nanogune)

The magnetic properties of atoms on metals are inherently connected with manybody interactions between the localized magnetic moment and the supporting surface. The Kondo effect is the one most frequently found. The energy scale of a Kondo ground state depends strongly on the exchange coupling between atom and surface and, consequently, on the surface local density of states at the Fermi level (LDOS). Here, we study the effect of the LDOS on the magnetic ground state of Co atoms on Ag(111) by constructing artificial atomic structures, which confine surface states electrons and modulate in a predesigned manner the LDOS. By intentionally placing individual atoms at sites with difference LDOS, the Kondo temperature can be varied between 60 to 145 K, demonstrating the precise control of the substrate LDOS is crucial for quantitative analysis of the Kondo state.

MA 19.9 Tue 12:30 H33

Controlling spin stability by a vector magnetic field and atom manipulation — •Deung-Jang Choi[1,2], Shichao Yan[1,2], and Sebastian Loth[1,2] — [1]Max Planck Research Group-Dynamics of Nanoelectronic Systems, Center for Free-Electron Laser Science, Hamburg — [2]Max Planck Institute for Solid State Research, Stuttgart

A time-resolving sub-Kelvin scanning tunneling microscope (STM) is used to manipulate atoms and build nanostructures such as atomic chains or arrays. We show that not only static but also dynamic properties of nanostructures can be controlled. We place magnetic atoms into close proximity of existing nanostructures. This modifies available spin relaxation pathways. The resulting variations in the spin relaxation times and spin polarization can be monitored by an all-electronic pump-probe technique [1]. In this way even weak spin coupling can be detected. A vector magnetic field provides additional control over the mixing of spin states without changing the atomic configuration of a nanostructure. For example, we compare the angular dependence of the spin anisotropy for individual Fe atoms and Fe in few-atom arrays. The combination of vector magnetic fields with atom manipulation provides a great deal of control over the behavior of atomic

spins making it possible to study spin dynamics at atomic dimensions.

[1] S. Loth, M. Etzkorn, C. P. Lutz, D. M. Eigler, A. J. Heinrich, Science 329, 1628 (2010).

MA 19.10 Tue 12:45 H33

Atomically assembled antiferromagnets — •Sebastian Loth — Max Planck Research Group-Dynamics of Nanoelectronic Systems, Center for Free-Electron Laser Science, Hamburg — Max Planck Institute for Solid State Research, Stuttgart

When atoms are placed into regular arrays their magnetic moments can interact and form long-range ordered magnetic states. In particular antiferromagnetic spin coupling creates a large variety of possible collective states. We use low-temperature scanning tunneling microscopy to construct few-atom antiferromagnets. Their shapes can be defined precisely by atom manipulation. In this way uncompensated magnetic moments at the nanoparticle's edge can be avoided. We use such spin-compensated atomic arrays to study the intrinsic dynamics of nanoscale antiferromagnets [1]. For two-dimensional arrays of growing size we can trace the transition from the quantum mechanical singlet ground state to doubly degenerate Neel-type states. Arrays with ten or more atoms can be stable in each state for several hours but current-induced switching between the metastable spin states proceeds at nanosecond speed. These properties enable a model demonstration of dense magnetic data storage using antiferromagnets memory elements.

[1] S. Loth, S. Baumann, C. P. Lutz, D. M. Eigler, A. J. Heinrich, Science 335, 196 (2012).

MA 19.11 Tue 13:00 H33

Epitactical grown Kondo lattices spanning different localization regimes of the Ce 4f electrons — •Holger Schwab, Mattia Mulazzi, and Friedrich Reinert — Physikalisches Institut, Experimentelle Physik VII, Universität Würzburg, D-97074 Würzburg, Germany

Ce surface alloys promise to be the choice of materials to study transformations of the electronic band structure during low temperature phase transitions in Kondo lattices. [1] The low temperature behaviour of Ce based Kondo systems strongly depends on the energy scales in the Ce atom and the hybridization between the Ce 4f orbitals and the conduction band. [2] Probing the Ce 4f spectral function [3] or the Ce 3d states therefore allows to preliminarily characterize and select such compounds. With XPS (X-ray Photoelectron Spectroscopy) of the Ce 3d states we investigated Ce surface alloys on Ag(111), Pt(111) and Pd(111) surfaces. Based on a GS-fit [4] to these data we were able to compare and rank the parameters responsible for the behaviour of these alloys in the single impurity regime of the Kondo lattice.

[1] M. Klein et al.,Phys. Rev. Lett. 106, 186407 (2011), P. Coleman, Science 327, 969 (2010)
[2] F. Patthey et al., Phys. Rev. B 42, 8864 (1990)
[3] H. Schwab et al., Phys. Rev. B 85, 125130 (2012)
[4] O. Gunnarsson et al., Phys. Rev. B 28, 4315 (1983)

MA 20: Graphene: Characterization and devices (HL, jointly with DS, MA, O, TT)

Time: Wednesday 9:30–13:00 Location: H17

MA 20.1 Wed 9:30 H17

Polarization dependence of phonon modes in graphene nanoribbons — •Felix Kampmann[1], Nils Scheuschner[1], Bernat Terrés[2,3], Christoph Stampfer[2,3], and Janina Maultzsch[1] — [1]Institut für Festkörperphysik, TU Berlin, Hardenbergstraße 36, 10623 Berlin, Germany, EU — [2]JARA-FIT and II. Institute of Physics B, RWTH Aachen University, Aachen, Germany, EU — [3]Peter Grünberg Institute (PGI-6/8/9), Forschungszentrum Jülich, Jülich, Germany, EU

Polarization dependent Raman spectroscopy has lately been used to investigate the edge states of few layer graphene revealing insight into the selection rules of their Raman modes.

Here we report polarization dependent Raman measurements on single-layer graphene nanoribbons with varying width down to 30 nm.

We show that the $\cos^2(\theta)$ behavior of the intensity ratio I(D)/I(G) can be reproduced as it has already been known for the graphene edge states. Furthermore we found a similar behavior for I(D′)/I(G) and discuss the dependence on the nanoribbon width.

MA 20.2 Wed 9:45 H17

Manifestation of charged and strained graphene layers in the Raman response of graphite intercalation compounds — Julio Chacon-Torres[1], •Ludger Wirtz[2], and Thomas Pichler[1] — [1]Faculty of Physics, University of Vienna, Austria — [2]Physics and Material Sciences Unit, University of Luxembourg, Luxembourg

We present recent Raman measurements together with a detailed analysis of potassium graphite intercalation compounds (GICs): stage II to stage VI (where stage n means one intercalant layer after every nth graphene layer). By ab-initio calculations of the charge densities and the electronic band dispersions, we demonstrate that most (but not all) of the charge donated by the K atoms remains on the outer graphene layers, i.e., the once adjacent to the intercalant layer. This leads to an electronic decoupling of the inner (uncharged) from the outer (charged) layers and consequently also to a decoupling of the corresponding Raman spectra: The G-line splits into two peaks and the 2D line is entirely due to the uncharged inner layers while the 2D line of the outer layers is suppressed due to the strong charging. The quantitative interpretation of the peak positions requires that the internal strain of the graphene layers is taken into account. This allows to unambiguously identify the Raman response of strained charged and uncharged graphene layers and to correlate it to the in-plane lattice constant. Raman spectroscopy is thus a very powerful tool to identify internal strain in single and few-layer graphene as well as to to identify the strain in nanoelectronic and optoelectronic devices or the local interfacial strain in other graphene composites.

MA 20.3 Wed 10:00 H17

C–axis transport in graphite and few–layered–graphene — •Ole Pfoch, Yuri Koval, Michael Enzelberger, and Paul Müller — Department of Physics and Interdisciplinary Center for Molecular Materials, Universität Erlangen

Electrical transport in single or few layered graphene was intensively investigated during the last decade. However, most experiments were performed with electronic transport in the plane. Measurements in perpendicular direction are rare and the results are rather sensitive to materials properties. For instance, the literature data for the anisotropy of the electrical conductivity in plane and along the c–axis varies between 100 and 10 000. One of the reasons for the wide spread of anisotropy data might be a significant influence of structural defects. We reduce the influence of these defects by decreasing the cross section of the measured structures down to $2 \times 2\,\mu m^2$. Mesa type structures were prepared by e–beam lithography and O_2–plasma etching. The influence of the mesa size on the c–axis conductivity and its temperature dependence were investigated. We have found that the c–axis conductivity is rather sensitive to the prehistory of the sample and to the origin of the graphite material. We present our recent results and discuss the mechanism of c–axis electrical transport.

MA 20.4 Wed 10:15 H17

Electronic transport of metallic thin films and islands on graphene with scanning tunneling spectroscopy — •Anne Holtsch, Hussein Shanak, Haibin Gao, and Uwe Hartmann — Institute for Experimental Physics, Saarland University, P.O. Box 151150, 66041 Saarbrücken

Electronic properties of graphene without and with metallic thin films and islands on top are investigated. The graphene layers are epitaxially grown on rhodium using a chemical vapor deposition (CVD) method. In a second step, metallic thin films and islands (Au) are deposited onto the surface of the graphene layer. Investigations are performed by using scanning tunneling spectroscopy (STS). An introduction to a method for an automated comparison and characterization of different spectroscopic curves is the focus of this presentation. This method will be used to clarify which impact the metallic thin films and islands have on the electronic properties of graphene. Therefore a comparison between the results obtained from graphene samples without and with metalic thin films and islands is presented.

MA 20.5 Wed 10:30 H17

Fano-Profiles in HOPG and graphene flakes. — •Matthias Städter, Matthias Richter, and Dieter Schmeisser — Brandenburg University of Technology, Cottbus, Germany

We investigated the electronic structure of the valence and conduction band of HOPG by 2D resonant photoemission spectroscopy. Our aim is to understand the electronic structure of defects and inhomogeneities in graphene and related materials in more detail. From our measurements we find that the transition from the σ-band to the π^*-band at the M-point shows a characteristic Fano-Profile. A Fano-Profile occurs as the result of the interference of the band to band transition and a parallel transition to a discrete energy level within the band gap.The theory of Fano enables us to determine the energetic location of these discrete level. It is found to be several meV above the Fermi-Energy. Additional measurements on graphene flakes lead to similar results for the σ- to π^*-band transition and the location of the discrete energy state. With this we not only can determine the energetic states of defects but also get a better understanding of the origin of the Fano profile which is a particular detail of the resonant absorption process.

MA 20.6 Wed 10:45 H17

Multiple Auger Decay at resonant photo-excitation In carbon thin films — •Matthias Richter, Matthias Städter, Ioanna Paloumpa, and Dieter Schmeisser — Brandenburg University of Technology Cottbus, Applied Physics and Sensors, K.-Wachsmann-Allee 17, 03046 Cottbus, Germany

We use resonant photoemission at the C1s edge to study the electronic structure of HOPG, graphene flakes and monolayer graphene. We find remarkable differences in the profile of the Auger decay channels, which we attribute to an additional multiple-Auger with a three-hole final state. A prerequisite for the appearance of this decay mechanism is the existence of localized excitonic states, which cause the appearance of the multiple Auger decay. Defects (pits, holes, steps and kinks) can act as localized excitonic states. We use those effects to identify the existence and the quantity of such defect states within the π^*-band regime in carbon thin films, because the intensity of the three-hole Auger decay is varying with the defect density of the carbon films. The defect-excitonic states can be either localized in the band-gap at the M-point or in case of surface defects like steps, kinks or pits even at the K-point by losing the pure sp^2 character of the films. We find that the appearance of the multiple Auger decay is different for multilayer and monolayer graphene. In particular the interaction of impurities leads to broadening of the C1s core levels. The three-hole Auger decay spectroscopy is a new method to detect such contaminations with a high sensitivity.

MA 20.7 Wed 11:00 H17

Characterization of large-scale graphene CVD with far-infrared radiation — •Christian Cervetti[1], Boris Gorshunov[1,4,5], Elena Zhukova[1,4,5], Martin Dressel[1], Klaus Kern[2,3], Marko Burghard[2], and Lapo Bogani[1] — [1]1. Physikalisches Institut, Universität Stuttgart — [2]Max Planck Institut für Festkörperforschung — [3]Institute de Physique de la Matière Condensée, Ecole Polytechnique de Lausanne, Switzerland — [4]A.M.Prokhorov General Physics Institute, Russian Academy of Sciences, Russia — [5]Moscow Institute of Physics and Technology (State University), Russia

We use monochromatic terahertz (THz) spectrometer and standard Fourier-transform spectrometer to measure the conductance of large scale single layer graphene obtained by chemical vapor deposition. We demonstrate the extreme sensitivity of the THz conductance to copper particles produced on graphene during the transfer process, making THz spectroscopy a powerful tool for monitoring the removal of unwanted leftovers during the production of large scale graphene samples.

Coffee break

MA 20.8 Wed 11:30 H17

Terahertz generation in freely suspended graphene — •Andreas Brenneis[1], Leonhard Prechtel[1], Helmut Karl[2], Dieter Schuh[3], Werner Wegscheider[4], Li Song[5], Pulickel Ajayan[6], and Alexander W. Holleitner[1] — [1]Walter Schottky Institut and Physik-Department, TU München, Germany — [2]Institute of Physics, University of Augsburg, Germany — [3]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [4]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland — [5]University of Science and Technology of China — [6]Rice University, Houston, Texas, USA

We report on THz generation and picosecond photocurrents in freely suspended bilayers of graphene [1]. The graphene layers are connected to coplanar strip lines which serve as source and drain contacts. A pump laser pulse excites charge carrier in the graphene. The resulting charge carrier dynamics couple to the strip line circuit and propagate along the strip line. With a probe laser pulse focused onto an on-chip photo switch, the propagating signal is read out via a third contact with a picosecond time resolution. By varying the delay of the probe pulse relative to the pump pulse, the optoelectronic signal can be measured time-resolved. We discuss the generation of THz radiation, ultrafast displacement currents, and thermoelectric currents within the optically excited graphene. Financial support by the ERC-grant NanoREAL is acknowledged.

References: [1] L. Prechtel, L. Song, D. Schuh, P. Ajayan, W. Wegscheider, A.W. Holleitner, Nature Comm. 3, 646 (2012).

MA 20.9 Wed 11:45 H17

Broadband THz detection with graphene flakes — •Martin Mittendorff[1,2], Stephan Winnerl[1], Josef Kamann[3], Jonathan Eroms[3], Harald Schneider[1], and Manfred Helm[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Universität Dresden, Germany — [3]Universität Regensburg, Germany

We demonstrate a broadband THz detector based on graphene flakes, which are produced by scotch-tape method on SiO_2/Si, combined with a logarithmic periodic antenna. The antenna is coupled to the graphene flake with an interdigitated comb-like structure in the center. The detectors were characterized at roomtemperature using the free-electron laser FELBE at the Helmholtz-Zentrum Dresden-Rossendorf. The responsivity is above 1 nA/W for wavelengths from $30\mu m$ to $220\mu m$. The rise time of the measured signals is below 100 ps and their length is in the range of 200 ps, while the pulse duration of the FEL pulses is around 20ps. The effect of the antenna coupling could be confirmed via polarization dependent measurements. Due to the spectral bandwidth combined with high temporal resolution and simple handling these detectors can be very useful for timing purposes of short laser pulses.

MA 20.10 Wed 12:00 H17

Electrostatic force and Raman spectroscopy measurements on graphene replicating water layers on mica — •Vitalij Scenev, Philipp Lange, Nikolai Severin, and Jürgen P. Rabe — Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Deutschland

Recently it has been argued that graphenes exfoliated onto mica become hole-doped by the substrate and that the doping level can be blocked by molecular water interlayers confined during sample preparation [1]. We use Scanning Probe Microscopy (SPM), Electrostatic Force Microscopy (EFM) and Raman Spectroscopy to investigate both the structure and the electronic properties of graphene conforming to molecular water layers on the mica surface. The layers are fluid, since variation of ambient humidity allows to control in-situ the layer thicknesses in the range of a monolayer [2]. Our data imply that graphene is hole-doped by the water layers with the doping level increasing with the water layer thickness.

1. Shim, J., et al., Water-Gated Charge Doping of Graphene Induced by Mica Substrates. Nano letters, 2012. 12(2): p. 648-654.

2. Severin, N., et al., Reversible dewetting of a molecularly thin fluid water film in a soft graphene-mica slit pore. Nano letters, 2012. 12(2): p. 774-779.

MA 20.11 Wed 12:15 H17

Tailoring the graphene/silicon carbide interface for monolithic wafer-scale electronics — •Stefan Hertel[1], Daniel Waldmann[1], Johannes Jobst[1], Andreas Albert[1], Matthäus Albrecht[1], Sergey Reshanov[2], Adolf Schöner[2], Michael Krieger[1], and Heiko B. Weber[1] — [1]Chair for Applied Physics, Erlangen, Germany — [2]ACREO AB, Kista, Sweden

The vision of graphene as future material for electronic devices is derived from impressive material parameters. However, it is evident that graphene will not readily take over the role of a semiconductor. In particular, an efficient switch is lacking due to graphene's missing bandgap.

By focusing not only on the graphene layer, but considering the silicon carbide (SiC) substrate as an essential part of the system, we

developed an easy scheme to fabricate transistors with high ON/OFF ratio - suited for logic - by tailoring the interface between SiC and the graphene layer [1]. Therefore we currently work with two graphene materials on SiC: as grown monolayer graphene (MLG) and hydrogen intercalated quasi-freestanding bilayer graphene (QFBLG). We proved the high-quality ohmic contact of MLG to n-type SiC and also characterized the Schottky-like behavior of QFBLG.

Using these components we are currently able to demonstrate transistors with ON/OFF ratios exceeding 104 at room temperature in normally-on and normally-off operation mode. We present a concept for inverters using a resistor-transistor logic scheme.

[1] S. Hertel *et al.*, Nature Communications **3**, 957 (2012)

MA 20.12 Wed 12:30 H17

Electrical interfacing of cells with graphene field effect transistors — •Felix Rolf, Lucas H. Hess, Tobias Schneider, Benno Blaschke, Moritz Hauf, and Jose A. Garrido — Walter Schottky Institut, TU München

The next generation of neuroprosthetic devices will need novel solid-state sensors with improved performance. Increased signal detection capability, better mechanical and physiological compatibility with living tissue, and in general a higher stability in biological environments are among the main requirements. Due to its electronic and electrochemical characteristics, as well as its physico-chemical properties, graphene is one of the most suitable candidates to meet these demanding requirements.

In this talk, we will report on arrays of graphene solution-gated field effect transistors (G-SGFETs) which are able to detect the electrical activity of electrogenic cells. It will be discussed how the combination of high carrier mobilities in graphene and the large interfacial capacitance at the graphene/electrolyte interface results in such high signal sensitivities. Thereby it is possible for instance, to show the generation and propagation of action potentials in cardiomyocyte-like HL-1 cell cultures. Another application is the single cell-transistor coupling using Human Embryonic Kidney (HEK293) cells. In the latter case the response of the G-SGFETs to electrical activity as well as the cell chemical activity will be discussed. Our results confirm that G-SGFETs are able to outperform state-of-the-art devices, suggesting that G-SGFETs can play an important role in future bioelectronic systems.

MA 20.13 Wed 12:45 H17

Exploring the electronic performance of graphene FETs for bio-sensing — •Lucas Hess, Benno Blaschke, Max Seifert, and Jose Garrido — Walter Schottky Institut, TU München

For medical applications such as neuroprostheses and for fundamental research on neuronal communication, it is of utmost importance to develop a new generation of electronic devices which can effectively detect the electrical activity of nerve cells. The outstanding electronic and electrochemical performance of graphene hold great promise for bioelectronic applications. For instance, we have reported on arrays of CVD-grown graphene solution-gated FETs (SGFETs) for cell interfacing, demonstrating their ability to transduce with high resolution the electrical activity of individual electrogenic cells.

In this contribution, we will present a detailed discussion on the suitability of CVD-grown graphene SGFETs for in-electrolyte operation, together with a study of the effect of electrolyte composition on the device performance. The sensitivity of SGFETs is dominated by two characteristic parameters: transconductance and electronic noise, which will be analyzed in this talk by in-electrolyte Hall-effect experiments and low-frequency noise characterization. Finally, we will briefly report on the pH and ion sensitivity of graphene devices, highlighting the influence of the chosen substrate for the device fabrication, as well as the effect of surface contamination from the fabrication technology.

This work demonstrates the potential of graphene to outperform state-of-the-art Si-based devices for biosensor and bioelectronic applications.

MA 21: Thermoelectric and Spincaloric Transport in Nanostructures

Time: Wednesday 9:30–12:00 Location: H1

Invited Talk MA 21.1 Wed 9:30 H1

Transport in Old and New Thermoelectric Materials — •David Singh — Oak Ridge National Laboratory, USA

Thermoelectric performance is a multiply contra-indicated property of matter. For example, it requires (1) high thermopower and high electrical conductivity, (2) high electrical conductivity and low thermal conductivity and (3) low thermal conductivity and high melting point. The keys to progress are finding an optimal balance and finding ways of using complex electronic and phononic structures to avoid the counter-indications mentioned above. In this talk, I discuss some of the issues involved in the context of recent results. These include the surprising doping dependence of the thermopower in PbTe and PbSe, and the interplay between acoustic and optical phonons in PbTe. Certain new materials as well as new concepts based on low dimensional electronic structures are discussed.

Invited Talk MA 21.2 Wed 10:00 H1

Binary oxide structures as model systems for thermoelectric transport — •Peter J. Klar and Christian Heiliger — I. Physikalisches Institut, Justus-Liebig-Universität

The binary oxides ZnO or the different phases of the Cu-O system can be considered to a large extent as semiconductors and can be fabricated by various techniques ranging from rf-sputtering to molecular beam epitaxy. Controlled doping to vary the free carrier concentration as well as alloying are feasible in the usual way. Standard semiconductor technologies can be employed to fabricate nano and microstructures. Thus, different morphologies can be achieved even for bulk material and micro and nanostructures can be prepared in a controlled way. A thorough understanding of the bulk thermoelectric properties of these oxides forms the basis of studying the various types of nano and microstructured samples. To obtain an understanding of the influence of grain boundaries, interfaces, and phase segregation on the thermoelectric transport, local and global properties need to be studied by experiment and to be analyzed by multi-scale theoretical models. Several examples of our approach will be presented.

Invited Talk MA 21.3 Wed 10:30 H1

Functional oxides films: from single crystals to polycrystalline substrates — •Wilfrid Prellier — Laboratoire CRISMAT, ENSICAEN, CNRS, 6 Bd Mal Juin, F-14050 Caen Cedex, France

Complex oxides represent a class of materials with several of exiting properties including magnetism, superconductivity or multiferroics. Thus, there are interesting for both fundamental research and applications. Using epitaxial strain, it is also possible in a thin film to modify the electronic properties as compare to bulk materials. While usually, the material is deposited on a single crystal to achieve the perfect epitaxy, it is also possible to synthesise the film on other type of substrate. In the first case, the film can be also be made artificially using the superlattices approach. In this talk, I will present recent results on superconductor superlattices [1,2] as well as our recent developed approach on thermoelectric films grown on a polycrystalline ceramic sample.[3] At the end, it will provide insight into current perspectives and future trends of functional oxide thin films.

[1]*P. Boullay et al., Phys. Rev. B 83, 125403 (2011). [2]*D. Di Castro et al, Phys. Rev. B 86, 134524 (2012). [3] *D. Pravarthana et al., submitted (2012)

Invited Talk MA 21.4 Wed 11:00 H1

The Planar Nernst Effect and the Search for Thermal Spin Currents in Ferromagnetic Metals — •Barry Zink — University of Denver, Denver, Colorado, USA

In recent years some groups have reported that a pure spin current can be generated simply by applying a thermal gradient to a ferromagnetic material. This effect, called the spin Seebeck effect (SSE), has generated tremendous interest in the interaction of heat, charge and spin in ferromagnetic systems. In this talk we will present our recent measurements of thermoelectric and thermomagnetic effects in thin film metallic ferromagnets made using a micromachined thermal isolation platform that removes potentially confounding effects introduced by a highly thermally conductive bulk substrate. The main result is the observation of a transverse thermopower, called the planar Nernst effect (PNE). Measurements of the field-dependent (traditional) Seebeck ef-

fect and anisotropic magnetoresistance (AMR) confirm that the PNE is caused by spin-dependent scattering. This PNE should therefore be present in any attempted measurement of the SSE in a metal system where spin-dependent scattering of electrons occurs. Furthermore our "zero substrate" experiment shows no signal with the symmetry of the SSE, suggesting that the presence of the substrate is required to cause such a signal. This work was performed in collaboration with A. D. Avery, and M. R. Pufall, and supported by the US NSF CAREER award (DMR-0847796)

Invited Talk MA 21.5 Wed 11:30 H1

Tunneling magneto thermopower in magnetic tunnel junction nanopillars — Niklas Liebing[1], Santiago Serrano-Guisan[1,2], Patryk Krzysteczko[1], Karsten Rott[3], Günter Reiss[3], Jürgen Langer[4], Berthold Ocker[4], and •Hans Werner Schumacher[1] — [1]PTB, Braunschweig, Germany — [2]INL, Braga, Portugal — [3]U. Bielefeld, Bielefeld, Germany — [4]Singulus AG, Kahl am Main, Germany

Magneto-thermoelectric properties of magnetic nanostructures have attracted a broad attention over the last years. However only recenly first studies of the magneto-thermoelectric properties of magnetic tunnelling junctions (MTJ) have been published. These studies included the prediction [1] and experimental observation [2-4] of tunnelling magneto thermo power (TMTP). In this talk we will discuss our recent results on TMTP of CoFeB/MgO/CoFeB MTJ nanopillars [3]. For TMTP measurements the thermally induced voltage V_T across the MTJ is measured as function of magnetic field. The thermopower signal V_T scales linearly with the temperature gradient and reveals a similar spin dependence as the TMR. We observe a spin-dependent change of the Seebeck coefficient of up to 0.2 mV/K and a correspondingly large TMTP ratio of up to 90 per cent. This might enable future spin-caloritronics applications of CoFeB/MgO/CoFeB based MTJs. [1] M. Czerner et al. Phys. Rev. B 83, 132405 (2011), [2] M. Walter et al., Nature Mat. 10, 742 (2011), [3] N. Liebing et al. PRL 107, 177201 (2011), [4] W. Lin et al., Nat. Comm. 3, 744 (2012).

MA 22: Transport: Molecular Electronics (jointly with CPP, HL, and MA)

Time: Wednesday 9:30–12:45 Location: H2

MA 22.1 Wed 9:30 H2

Inelastic scattering effects and electronic shot noise — •Amin Karimi, Markus Herz, and Elke Scheer — Department of Physics, University of Konstanz, 78457 Konstanz, Germany

The study of shot noise for junctions formed by single molecules offers interesting new information that cannot be easily obtained by other means. At low bias it allows determining the transmission probability and the number of current carrying conductance channels [1]. We investigate the effects of phonon scattering on the electronic current noise through nano junctions with mechanically controllable break junction (MCBJ). Equivalent measurements have recently been reported to be able to reveal inelastic transport contributions to the current through gold atomic contacts [2]. We developed a new and versatile measurement system enabling measurements of the noise in a rather broad range of conductance values from 0.01 G_0 to 1 G_0 without the necessity of double wiring. First results on gold atomic contacts and benzendithiol will be presented.

[1] D. Djukic and J. M. van Ruitenbeek, Nano Lett. 6, 789-793 (2006)
[2] M. Kumar, R. Avriller and J. M. van Ruitenbeek, Phys. Rev. Lett. 108, 146602 (2012)

MA 22.2 Wed 9:45 H2

Electrical Characterization of Single Molecules via MCBJ — •Matthias Wieser[1], Torsten Sendler[1], Shou-Peng Liu[2], Samuel Weisbrod[2], Zhuo Tang[2], Andreas Marx[2], Jannic Wolf[2], Elke Scheer[2], Francesca Moresco[3], Grebing Jochen[1], and Artur Erbe[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., D-01328 Dresden — [2]Universität Konstanz, D-78457 Konstanz — [3]Max Bergmann Center of Biomaterials, D-01069 Dresden

For future molecular electronics applications the detailed knowledge about the electrical transport properties of single molecules is very important. To achieve this goal we are using the mechanical controllable break junction technique in liquid environments in combination with insulating substrates. We characterize the electrical conductance and I-V characteristics of single molecules which consist of three phenyl rings connected by triple carbon bonds with two oxygen sidegroups binding to the central ring. The I-V characteristics are further investigated by creating 2D histograms for hundreds of I-V curves and by fitting a single level model which provides us the metal-molecule junction coupling constants and the molecular energy level.

MA 22.3 Wed 10:00 H2

Charge transmission through a molecular junction driven by a time–dependent voltage — •Yaroslav Zelinskyy[1,2], Yoram Selzer[3], and Volkhard May[1] — [1]Institut für Physik, Humboldt Universität zu Berlin, Newtonstraße 15, D-12489 Berlin, Germany — [2]Bogolubov Institute for Theoretical Physics, National Academy of Science of Ukraine, 14-b Metrologichna str., UA-03683, Kiev, Ukraine — [3]School of Chemistry, Tel Aviv University, Ramat Aviv, 69978 Tel Aviv, Israel

Time-dependent electron transport through a molecular junction driven by voltage pulses with a duration even in the sub-ps region is investigated theoretically. The transient behavior of the current is analyzed in focusing on the sequential transport regime and in utilizing a density matrix approach. As a quantity detectable in the experiment the averaged dc-current resulting from a sequence of voltage pulses is also calculated. The obtained data are analyzed with respect to their dependence on the voltage pulse shape, the magnitude and asymmetry of the lead-molecule coupling, and the mechanism and strength of intramolecular relaxation. All the findings are confronted with recent computations on transient currents due to optical excitation of the junction [1,2].

[1] L. Wang and V. May, Phys.Chem.Chem.Phys. 13, 8755 (2011)
[2] Y. Zelinskyy and V. May, Nano Lett. 12, 446 (2012)).

MA 22.4 Wed 10:15 H2

Surface Plasmon Enhanced Electroluminescence of a Molecular Junction — •Yuan Zhang[1,2], Yaroslav Zhelinskyy[1], and Volkhard May[1] — [1]Institut für Physik, Humboldt Universität zu Berlin, Newtonstraße 15, D-12489 Berlin, Germany — [2]University of Science and Technology Beijing, XueYuan Road 30, 100083 Beijing, P. R. China

There are some first experiments indicating surface plasmon enhanced emission of a molecular junction. We present a coherent theory for this phenomenon, which is based on our previous work on molecule metal nanoparticle complexes [1,2,3,4]. Ultilizing a density matrix description our theory accounts for electron transfer in junction, photon emission and energy exchange coupling between the molecule and spherical leads. As a central result, we report on a three order of magnitude enhanced molecular photon emission, which dependence on molecular and junction parameters are also discussed.

[1] Y. Zelinskyi, Y. Zhang, and V. May, J. Phys. Chem. A, DOI: 10.1021/jp305505c
[2] Y. Zhang, Y. Zelinskyy, and V. May, J. Phys. Chem. C, accepted
[3] Y. Zhang, Y. Zelinskyy, and V. May, J. Nanophot., in press
[4] Y. Zelinskyy and V. May, Nano Lett. **12**, 446 (2012)

MA 22.5 Wed 10:30 H2

Dynamics of a nano-scale rotor driven by single-electron tunneling — Alexander Croy[2] and •Alexander Eisfeld[1] — [1]MPIPKS Dresden — [2]Chalmers University of Technology S-412 96 Göteborg, Sweden

We investigate theoretically the dynamics and the charge transport properties of a rod-shaped nano-scale rotor, which is driven by a similar mechanism as the *nanomechanical single-electron transistor (NEMSET)*. We show that a static electric potential gradient can lead to self-excitation of oscillatory or continuous rotational motion. We identify the relevant parameters of the device and study the dependence of the dynamics on these parameters. We discuss how the dynamics are related to the measured current through the device. Notably, in the oscillatory regime we find a negative differential conductance. The current-voltage characteristics can be used to infer details of the sur-

rounding environment which is responsible for damping.

[1] A. Croy and A. Eisfeld, *EPL (Europhys Lett)* **98**, 68004

MA 22.6 Wed 10:45 H2

First-principles investigation of electron transport through molecular junctions in an STM configuration — •Shigeru Tsukamoto, Vasile Caciuc, Nicolae Atodiresei, and Stefan Blügel — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich

Molecular electronics is exciting by the perspective that various types of functionalities are potentially realized only by single molecules with unique electronic structures. A number of interesting experiments on the transport properties have been performed in an STM configuration, in which a probing tip approaches a molecule on a metal surface.

By means of first-principles methods, we report about a systematic series of calculations on electron transport through molecules in the STM configuration. The molecules to be investigated are a Terephthalic acid molecule and its derivatives, which chemisorb on Cu(110) surfaces.

Electron transmissions are investigated by varying the tip–molecule distance in an STM configuration, as well as by tuning molecular electronic structures. As approaching the tip toward the molecule, some of the transmission peaks originating from unoccupied states move to lower energy due to the hybridization of tip and molecular states. This peak-shift contributes to increasing the electron transmission around the Fermi energy, which is an essential property in molecular devices. This exhibits that in molecular electronics, not only the molecule itself but also the geometrical configuration between a molecule and the electrodes is an important parameter to determine the functionality.

15 min. break

MA 22.7 Wed 11:15 H2

STM theory for π-conjugated molecules on thin insulating films — •Benjamin Siegert, Andrea Donarini, Sandra Sobczyk, and Milena Grifoni — Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg

We present a microscopic STM theory, based on the reduced density matrix formalism, which is able to describe transport and topographical properties of interacting π-conjugated molecules on thin insulating films. Simulated current-voltage characteristics and constant height and constant current STM images for a Cu-Phthalocyanine (CuPc) molecule are presented as experimentally relevant examples. We predict negative differential conductance resulting from interference between degenerate many-body states of CuPc [1]. Criteria are given to find and identify the interference blocking scenario in experimental measurements.

[1] A. Donarini, B. Siegert, S. Sobczyk, and M. Grifoni, PRB **86**, 155451 (2012).

MA 22.8 Wed 11:30 H2

Influence of Electronic Properties of Graphene on Current-Voltage Characteristics of Molecule-Graphene Nanojunctions — •Ivan A. Pshenichnyuk, Pedro B. Coto, André Erpenbeck, and Michael Thoss — Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany

Graphene, thanks to its peculiar mechanical and electronic properties, is today considered as a perspective material in future electronics. Its well-known band structure with "zero band-gap" as well as the existence of so-called edge states leads to a non-trivial density of states distribution in graphene-based devices. This causes, in particular, distinctive current-voltage characteristics of molecule-graphene nanojunctions, where a single molecule is connected to two graphene nanosized contacts. We study the transport characteristics of graphene-based nanojunctions using tight-binding models and first-principles DFT calculations combined with the Landauer transport formalism.

MA 22.9 Wed 11:45 H2

Electron Transport properties of metallic carbon nanotubes with metal contacts — •Andreas Zienert[1], Jörg Schuster[2], and Thomas Gessner[1,2] — [1]Center for Microtechnologies, Chemnitz University of Technology, Chemnitz, Germany — [2]Fraunhofer Institute for Electronic Nano Systems, Chemnitz, Germany

Metallic carbon nanotubes (CNTs) are quasi ballistic one-dimensional conductors capable to carry large current densities. This makes them ideal candidates for applications in future microelectronic devices, partially replacing state-of-the-art copper interconnect lines. The performance of such a system not only depends on intrinsic properties of the CNTs but is also strongly affected by its size and the contact.

We investigate the transport properties of metal–CNT–metal devices theoretically, applying semiempirical (extended Hückel theory) and ab initio (density functional theory) electronic structure methods, combined with a Green's function formalism for ballistic transport at low bias. The study focuses on $(6, 0)$ CNTs of different length comparing the metal contacts Al, Cu, Pd, Pt, Ag, Au in a highly symmetric end-to-end configuration.

It turns out that Al forms the most transparent contacts, followed by Pd, Pt and Cu. The noble metals Au and Ag perform worse. Results are visualized and discussed in terms of the local density of states of the combined metal–nanotube systems and its isolated parts, as well as their contact distances, binding energies, and work functions.

MA 22.10 Wed 12:00 H2

First principles study of charge and heat transport through π-stacked molecules — •Thomas Hellmuth[1], Marius Bürkle[2], Fabian Pauly[3], and Gerd Schön[1] — [1]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Nanosystem Research Istitute, National Institute of Advanced Industrial Science and Technology, Japan — [3]Theorie der Nanostrukturen, Universität Konstanz, 78457 Konstanz, Germany

We analyze charge and heat transport properties of π-stacked, multilayered paracyclophane molecules using density functional theory combined with non-equilibrium Green's function techniques. The conductance of that class of molecules was measured in Ref. 1. Beside the elastic conductance we investigate the not yet measured thermopower and inelastic electron tunneling spectra (IETS). The transmission eigenchannels show that the current is mainly carried by the π system of the paracyclophane molecules and by taking into account different contact geometries, we find that this is independent of the binding motif. While the conductance decays exponentially with increasing molecular length, the thermopower increases linearly and may change its sign. Similarly, we analyze how the IETS and the heat transport depend on the molecular length and vibrational modes in the specific junction geometries.

[1] S. T. Schneebeli *et al.* J. Am. Chem. Soc. **133**, 2136 (2011)

MA 22.11 Wed 12:15 H2

Spin selective transport in chiral systems — •Rafael Gutierrez, Thomas Brumme, and Gianaurelio Cuniberti — Institute for Materials Science and Max Bergmann Center of Biomaterials, Dresden University of Technology, 01062 Dresden, Germany

Recent experiments have demonstrated that the transmission of electrons through layers of chiral molecules can be strongly spin-dependent [1,2]. Here, we extend a previous model [3] to discuss the interrelation between the observed effect and the presence of a spin-orbit coupling interaction induced by helical electrostatic fields. Hereby, we present a minimal model Hamiltonian based on a representation of the Schroedinger equation on a helical pathway and discuss the influence of several parameters on the spin polarization. Complementary to it, full 3D wave packet propagation is discussed in the presence of spin-orbit coupling. Our results suggest that a spin polarization can be induced as a result of the symmetry of the system. However, it appears that a full 3D description of the problem may be necessary.

[1] B. Goehler, V. Hamelbeck, T. Z. Markus, M. Kettner, G. F. Hanne, Z. Vager, R. Naaman, H. Zacharias, Science **331**, 894 (2011)
[2] Z. Xie, T. Z. Markus, S. R. Cohen, Z. Vager, R. Gutierrez, R. Naaman, Nano Letters **11**, 4652 (2011)
[3] R. Gutierrez, E. Diaz, R. Naaman, G. Cuniberti, Phys. Rev. B **85**, 081404(R) (2012)

MA 22.12 Wed 12:30 H2

Full ab initio description of strong electronic correlations in molecular devices — •David Jacob — Max-Planck-Institut für Mikrostrukturphysik, Halle

In order to obtain a *full* first-principles description of the correlated electronic structure and transport properties of nanoscopic devices we combine the so-called Coulomb-Hole-Screened-Exchange (COHSEX) approximation with more sophisticated many-body techniques such as the Dynamical Mean-Field Theory (DMFT). While the former yields an effective mean-field description of the weakly correlated conduction

electrons, the latter describes the dynamic correlations of the strongly interacting electrons in the $3d$- or $4f$-shells of transition metal atoms. The combination of DMFT with COHSEX instead of Density Functional Theory (DFT) improves upon our recently developed "Molecular DMFT" approach [1,2] in two important aspects: First, the COHSEX yields the effective Coulomb interaction U for the strongly interacting electrons. Second, unlike in DFT+DMFT calculations the double-counting correction for COHSEX+DMFT is exactly known and straight-forward to calculate. With this approach it is now possible to actually predict e.g. the occurance of the Kondo effect in magnetic atoms and molecules on metal surfaces and attached to metallic leads, and to investigate the complex nature of the Kondo effect in these sytems.

[1] D. Jacob *et al.*, PRL **103**, 016803 (2009); PRB **82**, 195115 (2010)
[2] M. Karolak *et al.*, PRL **107**, 146604 (2011)

MA 23: Spin Effects in Molecules at Surfaces (jointly with DS,O)

Time: Wednesday 9:30–12:15 Location: H23

MA 23.1 Wed 9:30 H23

Weak Coupling Kondo Effect in a Purely Organic Molecule: Universal Temperature and Magnetic Field Dependence — •Markus Ternes[1], Steffen Kahle[1], Yung-hui Zhang[1], Tobias Herden[1], Uta Schlickum[1], Peter Wahl[1,2], and Klaus Kern[1,3] — [1]Max-Planck-Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany — [2]School of Physics and Astronomy, University of St. Andrews, North Haugh, St. Andrews, Scotland — [3]Institut de Physique de la Matière Condensée, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

The Kondo effect is one of the most intriguing any-particle phenomenon in solid-state physics due to the simplicity of the underlying model: the scattering of itinerant electrons at a localized spin.[1] It has been intensely studied on the single atomic and molecular level by scanning tunneling spectroscopy (STS) in the last two decades; however a quantitative comparison with theoretical predictions remained challenging due to orbital degeneracies and a spin quantum number higher than $\frac{1}{2}$. Here, we present STS measurements on an purely organic radical coupled to the conduction electrons of a Au(111) surface. The observed zero bias anomaly is due to a spin $\frac{1}{2}$ Kondo screening in the weak coupling limit. We can describe the temperature and magnetic field dependence of the spectral features practically parameter free by perturbation theory allowing quantitative tests on more complex theoretical models.

[1] A. C. Hewson, 1997: The Kondo Problem to Heavy Fermions, Cambridge University Press

MA 23.2 Wed 9:45 H23

Density Functional Investigation of a Phthalocyanine Based Spin Transfer Material — •Rico Friedrich[1], Susi Lindner[2], Torsten Hahn[1], Claudia Loose[1], Martin Knupfer[2], and Jens Kortus[1] — [1]TU Bergakademie Freiberg, Freiberg, Germany — [2]IFW Dresden, Dresden, Germany

Interfaces were found to be of outstanding importance for electronic and spin transfer purposes especially in molecular spintronics [1]. Recently it has been demonstrated that an organic interface purely made from metal phthalocyanines namely manganese phthalocyanine (MnPc) and perfluorinated cobalt phthalocyanine (F_{16}CoPc) exhibits a charge and spintransfer at the interface between both molecules [2]. In this talk we present a systematic theoretical investigation of the phthalocyanine based dimer $MnPc^{\delta+}/F_{16}CoPc^{\delta-}$ within density functional theory framework. For all considered stackings a charge transfer from MnPc to F_{16}CoPc is observed which outlines this behavior as an intrinsic property of the molecular pair. In addition a ferromagnetic coupling ($S = 2$) of the molecular magnetic moments within the dimer is always observed due to 90° superexchange and direct exchange contributions. The comparison of the calculated absorption spectra of the geometrical arrangements to the experimentally recorded electron energy-loss spectrum strongly indicates the β-geometry to be preferred over all others. Only for this geometry an experimentally observed excitation around 0.6 eV is reproduced by the calculation.

[1] S. Sanvito, Nature Physics **6**, 562, (2010).
[2] S. Lindner *et al.*, Phys. Rev. Lett. **109**, 027601, (2012).

MA 23.3 Wed 10:00 H23

Superexchange-mediated ferromagnetic coupling in two-dimensional Ni-TCNQ networks on metal surfaces — •Sebastian Stepanow[1], Nasiba Abdurakhmanova[1], Tzu-Chun Tseng[1], Alexander Langner[1], Christopher Kley[1], Violetta Sessi[2], and Klaus Kern[1,3] — [1]MPI-FKF Stuttgart — [2]ESRF Grenoble — [3]EPFL Lausanne

We investigate the magnetic coupling of Ni centers embedded in two-dimensional metal-coordination networks self-assembled from 7,7,8,8-Tetracyanoquinodimethane (TCNQ) molecules on Ag(100) and Au(111) surfaces. X-ray magnetic circular dichroism (XMCD) measurements show that single Ni adatom impurities assume a spin-quenched configuration on both surfaces, while Ni atoms coordinating to TCNQ ligands recover their magnetic moment and exhibit ferromagnetic coupling. The valence state and the ferromagnetic coupling strength of the Ni coordination centers depend crucially on the underlying substrate due to the different charge state of the TCNQ ligands on the two surfaces. The results suggest a superexchange coupling mechanism via the TCNQ ligands.

MA 23.4 Wed 10:15 H23

Interface magnetism of the phenalenyl based molecular dimer adsorbed on a ferromagnetic surface — •Nicolae Atodiresei, Vasile Caciuc, and Stefan Blügel — Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Molecular based magnetic units represent a very exciting avenue in designing and building future data storage, sensing and computing multifunctional devices. The density functional theory (DFT) provides a framework that reliably describes the electronic properties of molecules adsorbed on magnetic surfaces which are an essential perquisite for the design an understanding of the functionality of hybrid organic molecular spintronic devices. We will present *ab initio* studies performed to understand the interaction of a phenalenyl (PLY) based molecular dimer with a ferromagnetic Co surface. Charge transfer and hybridization between the atomic p_z orbitals of the PLY with the $d-$orbitals of the Co atoms create new hybrid metal-organic interface states [1,2] that lead to a large interfacial magnetoresistance near room temperature as measured in experiments [3]. Furthermore, our studies demonstrate the decisive role played by the van der Waals interactions in correctly describing the interaction between aromatic PLY dimers and metallic surfaces.

[1] N. Atodiresei *et al.*, Phys. Rev. Lett. **105**, 066601 (2010).
[2] N. Atodiresei *et al.*, Phys. Rev. B **84**, 172402 (2011).
[3] K. V. Raman *et al.*, accepted for publication in Nature (2012).

MA 23.5 Wed 10:30 H23

Magnetism and molecule-surface interaction in transition metal porphyrin molecules on Cu(001) — •H. C. Herper[1,2], S. Bhandary[2], M. Bernien[3], C. F. Hermanns[3], A. Krüger[3], E. Weschke[4], C. Czekelius[5], C. Weis[1], C. Antoniak[1], B. Krumme[1], J. Miguel[3], D. Bovenschen[1], B. Sanyal[2], W. Kuch[3], H. Wende[1], and O. Eriksson[2] — [1]Fakultät für Physik und CeNIDE, Universität Duisburg-Essen, Germany — [2]Department of Physics and Astronomy, Uppsala University, Sweden — [3]Institut für Experimentalphysik, Freie Universität Berlin, Germany — [4]Helmholtz-Zentrum Berlin, Germany — [5]Institut für Chemie und Biochemie, Freie Universität Berlin, Germany

We present a combined theoretical and experimental study of Fe(Co) porphyrin molecules on (O)/Cu(001) surfaces. The interaction between nonmagnetic surfaces and molecules is weak, hence the anisotropy of the molecule can be studied together with the influence of ligands and hybridization effects with the surface. Magnetic and structural properties have been investigated within DFT and angle-dependent X-ray absorption spectroscopy at the Fe $L_{2,3}$ edge. The magnetic dipole term is calculated to allow for comparison between spin moments from experiment and theory. The angle dependence of the calculated effective moments is in good agreement with the experimental findings. An intermediate spin state is obtained independent

from the presence of an oxygen layer on the surface, which affects the hybridization between surface and molecule. A high-spin state can be realized by adding Cl or O ligands, which cause a stretching of the metal center-N bond.

15 min. break

MA 23.6 Wed 11:00 H23

Magnetic coupling of Cobaltocene on magnetic surfaces through a graphene layer — •Simone Marocchi[1,2], Paolo Ferriani[3], Stefan Heinze[3], Franca Manghi[1,2], and Valerio Bellini[2,4] — [1]University of Modena and Reggio Emilia, Modena, Italy — [2]CNR Istituto di Nanoscienze S3, Modena, Italy — [3]Institute of Theoretical Physics and Astrophysics, Kiel, Germany — [4]CNR Istituto di Struttura della Materia, Trieste, Italy

The ability to improve the current electronic devices appear to be increasingly connected with the development of the molecule-based electronics [1] and spintronics [2]. We have concentrated our study, employing state-of-the-art density functional theory calculations, on the structural and magnetic properties of the Cobaltocene ($CoCp_2$) adsorbed on graphene deposited on slab of Ni(111). This molecule has been chosen because of its electronic structure rather unique among the metallocenes [3]. In several article has been pointed also out that graphene on Nickel (111) has mainly two energetically favored adsorption modes, namely top-fcc and bridge-top [4]. We will show how the magnitude of the magnetic coupling is drastically influenced by the structural factors named above and may vary by tens of meV. We further show how this coupling could be tuned by the intercalation of a magnetic monolayer, e.g. Fe and Co, between graphene and the Ni subtrate, and discuss the role of the graphene layer.

[1] X. Y. Zhu, Surf. Sci. Rep. 56, 1 (2004). [2] S. Sanvito, Chem. Soc. Rev. 40, 3336 (2011). [3] Y. Li, et al., Phys. Rev. B 83, 195443 (2011). [4] W. Zhao, et al., J. Phys. Chem. Lett. 2, 759 (2011).

MA 23.7 Wed 11:15 H23

Atomic-scale Inversion of Spin Polarisation above an Organic-Antiferromagnetic Interface — •Nuala Mai Caffrey, Paolo Ferriani, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, Christian-Albrechts-Universität zu Kiel

The emerging field of organic spintronics aims to combine the advantantages of molecular electronics such as device miniaturisation and fabrication ease with the massive potential for application inherent in spintronics. Potential devices use organic molecules to control and manipulate spin-polarised signals. Such molecules are generally contacted with non-organic materials. As such, it is vital to understand the magneto-organic interface. It has been previously found that even the simplest non-magnetic molecule is capable of inverting the spin polarisation emerging from the clean ferromagnetic surface. We consider here an antiferromagnetic surface: a monolayer of Mn on a W(110) substrate. We perform *ab-initio* calculations in order to investigate the interface between simple organic molecules, both magnetic and non-magnetic, and an antiferromagnetic surface. The molecules considered include benzene (C_6H_6), cyclooctatetraene (C_8H_8) and small transition metal - benzene complexes. Simulated spin-polarised scanning tunnelling micoscopy (SP-STM) images are presented. They show that the exact magnitude and sign of the spin polarisation in the vacuum above the molecule is strongly dependent on the bonding details at the interface and due to the antiferromagnetic surface it exhibits a strong intra-molecular spatial dependence.

MA 23.8 Wed 11:30 H23

Spin Crossover in a Vacuum-Deposited Submonolayer of a Molecular Iron(II) Complex — •Matthias Bernien[1], Dennis Wiedemann[2], Christian F. Hermanns[1], Alex Krüger[1], Daniela Rolf[1], Wolfgang Kroener[3], Paul Müller[3], Andreas Grohmann[2], and Wolfgang Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Institut für Chemie, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin, Germany — [3]Department of Physics, Universität Erlangen-Nürnberg, Erwin-Rommel-Straße 1, 91058 Erlangen, Germany

Spin-state switching of transition-metal complexes (spin crossover) is sensitive to a variety of tiny perturbations. It is often found to be suppressed for molecules directly adsorbed on solid surfaces. We present X-ray absorption spectroscopy measurements of a submonolayer of [$Fe^{II}(NCS)_2$L] (L: 1-{6-[1,1-di(pyridin-2-yl)ethyl]-pyridin-2-yl}-*N*,*N*-dimethylmethanamine) deposited on a highly oriented pyrolytic graphite substrate in ultrahigh vacuum. These molecules undergo a thermally induced, fully reversible, gradual spin crossover with a transition temperature of $T_{1/2} = 235(6)$ K and a transition width of $\Delta T_{80} = 115(8)$ K. Our results show that, by using a carbon-based substrate, the spin-crossover behavior can be preserved even for molecules that are in direct contact with a solid surface.

Financial support by the DFG (Sfb 658: Elementary Processes in Molecular Switches on Surfaces) is gratefully acknowledged.

MA 23.9 Wed 11:45 H23

Single spin-crossover molecules triggered with a STM — •Manuel Gruber[1,2], Toshio Miyamachi[1], Martin Bowen[2], Samy Boukari[2], Eric Beaurepaire[2], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Karlsruher Institut für Technologie, Germany — [2]IPCMS (UMR 7504 UdS-CNRS) and Labex NIE, Strasbourg, France

A nano-scale molecular switch can be used to store information in a single molecule. The conductance of the molecule changes when switched and can be electrically detected. Spin crossover (SCO) molecules consisting of organic ligands around a transition metal ion are known to be switchable between a high- and a low-spin state by external stimuli [1]. It is the ultimate aim to achieve combined spin and conduction switching functionality on the level of individual molecules.

Fe(1,10-phenanthroline)2(NCS)2 molecules, SCO complexes, were deposited on Cu(100) and CuN/Cu(100) surfaces and studied with a scanning tunneling microscope (STM) in ultra-high vacuum at 4K.

Both spin species coexist at low temperatures as deduced from spectroscopic STM data. While on bare Cu(100), the molecules cannot be switched between the two spin states, molecules on CuN can individually and reproducibly be switched between a high-spin, high-conduction state and a low-spin, low-conduction state. This difference is explained by the role of the CuN layer to decouple the molecules from the metallic surface [2].

[1] P. Gütlich et al., Chem. Soc. Rev. 29, 419 (2000). [2] T. Miyamachi et al., Nat. Commun. 3, 938 (2012).

MA 23.10 Wed 12:00 H23

Beyond the Heisenberg model: Anisotropic exchange interaction between a Cu-tetraazaporphyrin monolayer and Fe3O4(100) — •Hans-Joachim Elmers[1], Julia Klanke[2], Eva Rentschler[2], Katerina Medjanik[1], Dmytro Kutnyakhov[1], Gerd Schönhense[1], Sergey A. Krasnikov[3], Igor V. Shvets[3], Stefan Schuppler[4], Peter Nagel[4], and Michael Merz[4] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55128 Mainz, Germany — [2]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany — [3]Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN) — [4]Karlsruhe Institute of Technology, Institut für Festkörperphysik (IFP), D-76021 Karlsruhe, Germany

We investigated the Heisenberg exchange coupling between the single Cu spin of Cu-tetraazaporphyrin deposited on magnetite(100) and the ferromagnetic surface using x-ray magnetic circular dichroism (XMCD). In contrast to the common model we find an anisotropic exchange coupling depending on the orientation of the spin relative to the bonding direction. The exchange coupling is ferromagnetic for magnetization direction perpendicular to the surface and antiferromagnetic for in-plane magnetization direction. The anisotropy of the Heisenberg exchange coupling is attributed to an orbitally-dependent exchange Hamiltonian. We propose that the sign change results from the competition between ferromagnetic superexchange along Fe-N-Cu and antiferromagnetic superexchange along Fe-O-Cu with strength modified by the strong spin-orbit coupling. Funded by COMATT.

MA 24: Magnetic Imaging and Scattering Techniques

Time: Wednesday 9:30–12:15 Location: H22

MA 24.1 Wed 9:30 H22

Specular reflection from Ir(001) as efficient electron spin filter — •D. Kutnyakhov[1], P. Lushchyk[1], A. Fognini[2], D. Perriard[2], M. Kolbe[1], K. Medjanik[1], E. Fedchenko[1], S.A. Nepijko[1], H.J. Elmers[1], G. Salvatella[2], C. Stieger[2], R. Gort[2], T. Bähler[2], T. Michlmayer[2], Y. Acremann[2], A. Vaterlaus[2], F. Giebels[3], H. Gollisch[3], R. Feder[3], C. Tusche[4], A. Krasyuk[4], J. Kirschner[4], and G. Schönhense[1] — [1]Institut für Physik, Univ. Mainz — [2]Lab. für Festkörperphysik, ETH Zürich, Switzerland — [3]Universität Duisburg-Essen — [4]MPI für Mikrostrukturphysik, Halle

A novel spin polarimeter is described that can transport a full image by making use of k-parallel conservation in low-energy electron diffraction from an Ir(001)-surface, extending our previous work on W(001) [1, 2]. This spin-filter crystal provides a high analyzing power combined with a *lifetime* in UHV of a full day. For specular reflection at 45° scattering angle we found a good working point at 37eV scattering energy that shows a broad maximum of 5eV usable width. A second one at about 10eV exhibits a narrower profile <1eV but much higher figure of merit. A relativistic layer-KKR SPLEED calculation shows good agreement with measurements. The asymmetry function (Sherman function) reaches values of 0.7 which considerably reduces the significance of spurious asymmetries. The novel detector has been used in a time-resolved experiment in the femtosecond region at the free-electron laser FLASH at DESY. [1] C. Tusche et al., APL 99 (2011) 032505; [2] M. Kolbe et al., Phys. Rev. Lett. 107 (2011) 207601

Funded by Stiftung Innovation(886 and 1038) and BMBF(05K12UM2)

MA 24.2 Wed 9:45 H22

Universal correlated velocity and domain wall spin structure oscillations probed by direct dynamic imaging — •Mohamad-Assaad Mawass[1,2], André Bisig[2,3,4], Amelie Axt[1], Martin Stärk[3,4], Christoforos Moutafis[3,4], Jan Rhensius[3,4], Matthias Noske[2], Markus Weigand[2], Tolek Tyliszczak[5], Bartel Van Waeyenberge[6], Hermann Stoll[2], Gisela Schütz[2], and Mathias Kläui[1,3,4] — [1]Johannes Gutenberg-Universität Mainz, Germany — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany — [3]Paul Scherrer Institut, Villigen, Switzerland — [4]Universität Konstanz, Germany — [5]Advanced Light Source, LBNL, Berkeley, USA — [6]Ghent University, Ghent, Belgium

Magnetic memory, sensing and logic devices based on the motion of magnetic domain walls (DWs) rely on the precise control of the position and the velocity of individual magnetic DWs. Varying DW velocities have been predicted to result from intrinsic effects, such as oscillating DW spin structure transformations and extrinsic pinning due to imperfections. We use direct dynamic imaging of the nanoscale spin structure to investigate these predictions, revealing universal oscillating domain wall motion. As the origin, the oscillating magnetostatic energy reservoir is identified, which scales with the DW velocity. Imaging wall motion in rings with varying width, we correlate the velocity with the wall energy revealing wall inertia. This inertia also explains our observation of extrinsic pinning-dominated DW propagation at low velocities, while we are able to achieve reproducible wall motion for fast walls that overcome defect-pinning.

MA 24.3 Wed 10:00 H22

Imaging of magnetic domains in TbCo alloys with magnetic circular dichroism in two-photon photoemission electron microscopy — •Markus Rollinger[1], Pascal Melchior[1], Philip Thielen[1,2], Sabine Alebrand[1], Ute Bierbrauer[1], Christian Schneider[1], Stéphan Mangin[3], Mirko Cinchetti[1], and Martin Aeschlimann[1] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Germany — [3]Institut Jean Lamour, Université de Lorraine, France

We use magnetic circular dichroism in two-photon photoemission to image the magnetic domains of TbCo thin films with a photoemission electron microscope (PEEM). With a Time-of-flight analyzer we perform time- and energy-resolved measurements with a spatial resolution of only a few tens of nanometers. As excitation source, we use the second harmonic (3,1eV photon energy) of a Ti:sapphire oscillator. The two-photon-photoemission process delivers a distinctively visible magnetic circular dichroism, whose strength depends strongly on the kinetic energy of the observed photoemitted electrons.

We present a detailed analysis of the energy-resolved PEEM dichroism spectra and explain the origin of the observed effect. These results open the way to the investigation of all-optical control of the magnetization in high-anisotropy rare earth-transition metal alloys [1] by means of energy- and time-resolved PEEM.

[1] S. Alebrand et al., Applied Physics Letters 101, 162408 (2012)

MA 24.4 Wed 10:15 H22

Domain structure in the vicinity of a spin reorientation transition — •Maciej Dabrowski[1], Andreas K. Schmid[2], Marek Przybylski[1,3], and Jürgen Kirschner[1,4] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]National Centre for Electron Microscopy, Lawrence Berkeley National Laboratory, Berkeley, USA — [3]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [4]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

There are two non-equivalent magnetization directions in the sample plane if ferromagnetic thin films are grown on stepped (001) surfaces. Moreover, there are additional terms to the anisotropy energy due to the steps, which cause the magnetization to tilt differently from the film plane if the in-plane magnetization orientation is kept perpendicular to the steps or along the steps. The thickness driven spin reorientation transition (SRT) for Fe films grown on a stepped surface of Ag(001) was studied by spin-polarized low energy electron microscopy (SPLEEM). Direct imaging of magnetic domains and local magnetization orientation was performed using three orthogonal spin polarizations of the incident electron beam. While the Fe film thickness increases, stripe domains expand and align perpendicular to the step edges. Our experiment demonstrates that as soon as the magnetization starts to tilt from the sample plane, a discontinuous in-plane SRT occurs and the magnetization prefers to be oriented perpendicular to the step edges.

MA 24.5 Wed 10:30 H22

Domain pattern breakup in mesoscopic structures studied with x-ray microscopy — Stephanie Stevenson, Christoforos Moutafis, Laura Heyderman, Christoph Quitmann, and •Jörg Raabe — Paul Scherrer Institut, 5232 Villigen, Switzerland

We report on the modification of the ground state domain pattern in $Ni_{81}Fe_{19}$ square islands due to RF excitation as monitored by scanning transmission x-ray microscopy at the PolLux beamline of the Swiss Light Source. A sinusoidal continuous wave field is applied via a stripline to excite the magnetisation of structures with physical dimensions in the micrometer range, fabricated at the Laboratory for Micro- and Nano-technology (LMN) at the Paul Scherrer Institute. During the RF excitation, a breakup of the domain configuration into a metastable state occurs. This metastable state returns to the ground state when the excitation is removed. Micromagnetic simulations and experiment agree that the domain breakup nucleates from a high amplitude motion of the domain walls. Directly visualising such metastable states provides insight into the tailoring of RF excitations for vortex core reversal and domain reorientation processes.

MA 24.6 Wed 10:45 H22

Magnetic dichroism in angle-resolved hard x-ray photoemission from amorphous Gd-Fe films — •Hans-Joachim Elmers[1], Andrei Gloskovskii[2], Gerd Schönhense[1], Alisa Chernenkaya[1], Katerina Medjanik[1], Mirko Emmel[1], and Gerhard Jakob[1] — [1]Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany — [2]Deutsches Elektronen-Synchrotron, Experimental Physics and Materials Science, Germany

The bulk sensitivity of hard x-ray photoelectron spectroscopy (HAXPES) in combination with circularly polarized radiation of the P09 beamline at PETRA III enables the investigation of the magnetic properties of capped films. We have determined the temperature dependence of the magnetic dichroism in the Fe 2p and in the Gd 3d states in amorphous Gd-Fe films. The magnetic dichroism reflects the stronger temperature dependence of Gd moments compared to Fe moments according to atomistic models. We resolved the exchange splitted Gd 3d5/2 sub states and found a significant temperature dependence of

the splitting which is attributed to a temperature dependent exchange energy. Funded by COMATT.

MA 24.7 Wed 11:00 H22

Magneto-mechanical coupling of nickel nanorods with an elastic matrix studied by magneto-optical transmission measurements — •Christoph Schopphoven, Philipp Bender, Andreas Tschöpe, and Rainer Birringer — Universität des Saarlandes, Saarbrücken

The rotation of ferromagnetic nickel nanorods in a soft-elastic hydrogel matrix was investigated by magnetic field-dependent optical transmission of linearly polarized light. Nickel nanorods with an average diameter of 23nm and an average length of 125nm were prepared by pulsed electrodeposition of nickel into porous AAO-templates. Dissolution of the alumina layer in dilute NaOH with polyvinylpyrrolidone(PVP) added for steric stabilization and subsequent separation and purification resulted in a stable aqueous solution. The microstructure of the nanorods was characterized by electron microscopy and the magnetic properties were obtained through magnetization measurements. These rods were dispersed into gelatin sols at 60°C and cooled to room temperature. During gelation a homogeneous field was applied to align the rods in field direction. The rods were rotated by applying a field perpendicular to their orientation and the resulting rotation angle was determined through optical transmission measurements. These experimental results were used to calculate the shear modulus of the gelatin matrix and the energy transferred into elastic deformation of the hydrogel matrix.

MA 24.8 Wed 11:15 H22

Scanning probe magnetic field imaging with a single spin sensor — •Dominik Schmid-Lorch, Thomas Häberle, Friedemann Reinhard, and Jörg Wrachtrup — 3. Physikalisches Institut und Forschungszentrum SCoPE, Universität Stuttgart, Germany

We work on a novel magnetic field sensor that is based on the nitrogen-vacancy (NV)-color center in diamond. The electron spin structure of the NV-center allows us to perform optically detected electron spin resonance (ESR) measurements, which can be made sensitive to the ambient magnetic field. Mounted to the tip of an AFM, these atomic-sized color centers promise an even higher spatial resolution than the MFM [1] while reducing back-action on the sample to a minimum.

I present the principles of this technique as well as benchmark measurements on magnetic microstructures. Furthermore I compare the performance of different electron spin resonance (ESR) protocols used for magnetic imaging.

Applications of this technique are detection and imaging of single electron spins [2] and small nuclear spin ensembles.

[1] G. Balasubramanian et al., Nature Vol 455, 648-651 (2008)
[2] M.S. Grinolds et al., arXiv:1209.0203v1 (2012)

MA 24.9 Wed 11:30 H22

Magnetic small–angle neutron scattering of two–phase bulk ferromagnets — •Dirk Honecker and Andreas Michels — Laboratory for the Physics of Advanced Materials, University of Luxembourg, Luxembourg

Based on micromagnetic theory we have derived analytical expressions for the magnetic small–angle neutron scattering cross section of a two–phase ferromagnet. The approach – valid close to magnetic saturation – provides access to several features of the spin structure such as perturbing magnetic anisotropy and dipolar stray fields. The micromagnetic SANS model inherently explains the 'clover–leaf' type angular anisotropies, which were previously observed for several nanostructured magnetic materials. Analysis of experimental neutron data of an iron–based soft magnetic nanocomposite yields information on the exchange–stiffness constant as well as on the anisotropy and dipolar fields.

MA 24.10 Wed 11:45 H22

Local symmetries and their effect on resonant magnetic scattering in $YMn_{2-x}Fe_xO_5$ — •Sven Partzsch[1], Enrico Schierle[2], Jorge E. Hamann-Borrero[1], Eugen Weschke[2], Taichi Matsuda[3], Hiroki Wadati[3], Stuart B. Wilkins[4], Dmitri Souptel[1], Bernd Büchner[1], and Jochen Geck[1] — [1]IFW Dresden — [2]HZB Berlin — [3]University of Tokyo — [4]BNL Upton

Resonant magnetic x-ray scattering (RMXS) is a powerful experimental photon-in/photon-out probe to study the magnetic structure in an element specific way. The RMXS of a free atom is known and, in fact, this is very often used [1]. However, when a scatterer is embedded in a solid additional effects need to be considered [2].

We derive the scattering matrix of the Fe2 sites of $YMn_{2-x}Fe_xO_5$ at the Fe $L_{2,3}$ edge from azimuth scans. The principle axes of the scattering matrix are strongly energy dependent because of the orthorhombic space group, the magnetic moments pointing in all three crystallographic directions and the strong anisotropic ligand field of the square pyramids.

[1] J. P. Hannon et al., PRL, 61, 1245 (1988)
[2] M. W. Haverkort et al., PRB, 82, 094403 (2010)

MA 24.11 Wed 12:00 H22

Multiple ordering phenomena in the magnetic metal $SrCo_6O_{11}$ — •Sven Partzsch[1], Taichi Matsuda[2], Hiroki Wadati[2], Enrico Schierle[3], Eugen Weschke[3], Shintaro Ishiwata[2], Yoshinori Tokura[2], Bernd Büchner[1], and Jochen Geck[1] — [1]IFW Dresden — [2]University of Tokyo — [3]HZB Berlin

$SrCo_6O_{11}$ has a layered hexagonal crystal structure and is a novel type of giant magnetoresistance system [1]. So far magnetic structures were studied only by powder neutron diffraction measurements [2], which revealed an $a \times a \times 3c$ superstructure, consistent with the 1/3 magnetization plateau.

In this study we used single crystals of this material and performed resonant soft x-ray scattering (RSXS) to obtain more detailed magnetic structures. RSXS measurements were performed at the UE46-PGM1 beamline of BESSY II. At the Co L_3 edge we observed the $L = 2/3$, 1, 4/3 and 3/2 reflections in agreement with the neutron data [2]. But in addition there are reflections which can be decomposed into $L = 4/5$, 5/6, and 6/7. This points to the "devil's staircase" theoretically obtained from the simple axial next nearest neighbor Ising model.

[1] S. Ishiwata et al., Phys. Rev. Lett. 98, 217201 (2007)
[2] T. Saito et al., J. Magn. Magn. Mater. 310, 1584 (2007)

MA 25: Magnetic Heusler Compounds

Time: Wednesday 9:30–12:30 Location: H10

MA 25.1 Wed 9:30 H10

Crystal growth of $Co_2Cr_xFe_{1-x}Al$ Heusler compounds — •Ahmad Omar, Maria Dimitrakopoulou, Christian George Friedrich Blum, Horst Wendrock, Steven Rodan, Silke Hampel, Wolfgang L öser, Bernd B üchner, and Sabine Wurmehl — Leibniz Institute for Solid State and Materials Research, D-01171 Dresden, Germany

Heusler compounds find extensive application as materials for magnetic tunnel junctions and memory devices as many are predicted to be half-metallic ferromagnets and hence have much potential in spintronics. Unfortunately, data for thin films as well as bulk materials for many compositions are fraught with anomalies. The present work primarily highlights crystal growth of select Heusler compounds ($Co_2Cr_xFe_{1-x}Al$) as an attempt towards understanding the interplay between the structure and intrinsic properties. We have used the Optical Floating Zone technique for the growth process. Apart from a phase segregation in the as cast samples, a spinodal decomposition of the grown samples has been observed for compounds containing Cr. The extent and the effect of the spinodal decomposition has also been studied.

MA 25.2 Wed 9:45 H10

Electronic structure of Fe2CrSi beyond the generalized gradient approximation — •Markus Meinert — Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, 33615 Bielefeld, Germany

The ferromagnetic Heusler compound Fe_2CrSi has been predicted to be a half-metal from standard density functional theory calculations [1,2]. In the present study, we investigate the properties of Fe_2CrSi beyond the level of the generalized gradient approximation (GGA)

within density functional theory. We compare the LDA, several GGAs, meta-GGAs including the Tran-Blaha modified Becke-Johnson potential (mBJLDA), hybrid functionals, the $+U$ method, and one-shot GW. The TPSS and M06-L functionals, the mBJLDA model potential, GGA+U, and the hybrids predict Fe_2CrSi consistently as a semiconductor with a small majority and a larger minority gap. In most semilocal approximations we find a ferromagnetic groundstate, but M06-L, GGA+U, HSE06, and PBE0 predict Fe_2CrSi to be a ferrimagnet. The sensitivity of the groundstate of Fe_2CrSi makes this compound an ideal test case to assess the validity of the various available approximations for the density functional for the material class of $3d$ transition metal based Heusler compounds.

[1] Ishida et al., Mater. Trans. **47**, 464 (2006). [2] Luo et al., J. Phys. D: Appl. Phys. **40**, 7121 (2007).

MA 25.3 Wed 10:00 H10

Transport Investigations of Mn_3Si — •Frank Steckel, Steven Rodan, Regina Hermann, Christian G.F. Blum, Sabine Wurmehl, Bernd Büchner, and Christian Hess — Leibniz Institute for Solid State and Materials Research, Dresden, Deutschland

We investigate electronic and thermal transport phenomena of the itinerant antiferromagnet Mn_3Si, which has been suggested to be a prototype material for realizing half-metallic antiferromagnetism [1] with a spin density wave below 25 K. We measured a complete set of transport coefficients: the resistivity, the Hall effect as well as the thermal conductivity, the thermopower and the Nernst effect in the temperature range from 10 K up to 300 K. In the vicinity of the antiferromagnetic transition temperature we found pronounced anomalies in the transport coefficients and a large fluctuation regime which extends to temperatures much higher (up to about 150 K) than the antiferromagnetic ordering temperature.

[1] C. Pfleiderer et al., Phys. Rev. B 65 (2002) 172404

MA 25.4 Wed 10:15 H10

X-ray absorption spectroscopy and magnetic circular dichroism studies of $L1_0$-Mn-Ga thin films — •Manuel Glas[1], Daniel Ebke[2], Christian Sterwerf[1], Jan Schmalhorst[1], Catherine Jenkins[3], Elke Arenholz[3], and Günter Reiss[1] — [1]Thin Films and Physics of Nanostructures, Bielefeld University, Germany — [2]Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany — [3]Advanced Light Source Berkeley, CA, USA

The continuous miniaturization process for spintronic devices requires consistently new materials. In particular, materials with high spin polarization, high Curie temperature, high perpendicular magnetic anisotropy, low magnetic moment, and low magnetic damping have found a lot of interest, due to the predicted lower current densities for spin torque transfer switching. The tetragonally distorted $Mn_{3-x}Ga$ compound fulfils these properties and is therefore a promising candidate for STT-switching MRAM devices. To achieve a high TMR effect the interface between the electrodes and barrier plays an important role. Therefore we investigated the interface between a $Mn_{64}Ga_{36}$ electrode and a 2.3 nm thick MgO barrier by element specific X-ray absorption spectroscopy (XAS) and magnetic circular dichroism (XMCD). Additionally, we examined the effects of CoFeB sandwiched between the Mn-Ga and the MgO with different thicknesses, and the deposition method for the MgO capping layer on the formation of interfacial MnO. Element specific full hysteresis loops were taken to determine the easy magnetization axis of the Mn and Co, respectively.

MA 25.5 Wed 10:30 H10

Basic investigations of hard magnetic binary $Mn_{(3-x)}Ga$ bulk materials — •Hannes Stummer, Christian Blum, Wolfgang Löser, Sabine Wurmehl, and Bernd Büchner — Leibniz Institut für Festkörper- und Werkstoffforschung Dresden, Germany

Polycrystalline materials from the manganese rich part of the Manganese-Gallium phase system provide hard magnetic properties with high coercive fields and low saturation.[1] These binary intermetallic Heusler-type compounds assume as starting material for new permanent magnetic materials.[2] The presented investigations deal with the polycrystalline compounds, their micro- and crystal structure analysis in addition to the magnetic properties. The fundamental studies give information about the phase formation in the complex binary phase system of Mn-Ga. Also a new promising synthesis route for the crystallization of single-crystalline samples, needed for comprehensive magnetic measurements, is presented. Furthermore it is shown that by slightly changing of the material composition new permanent magnetic materials can be produced. [1]Balke et al., Appl. Phys. Lett. 90, 152504 (2007) [2]Winterlik et al., Physical Review B, 77, 054406 (2008)

MA 25.6 Wed 10:45 H10

Electronic properties of Heusler alloys investigated by X-ray magnetic linear dichroism — •Mirko Emmel[1], Ingo Krug[2], Daniel Gottlob[2], Alexey Alfonsov[3], Sabine Wurmehl[3], Hans-Joachim Elmers[1], and Gerhard Jakob[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany — [2]Forschungszentrum Jülich, Germany — [3]Leibniz-Institut für Festkörper- und Werkstoffforschung IFW-Dresden, Dresden, Germany

Theoretical calculations have indicated that XMLD spectra are much more sensitive to changes of the electronic structure compared to XMCD spectra [1]. Thus several thin films of Co_2FeSi have been prepared on a MgO(100) substrate to verify existing theoretical predictions. The films were prepared by DC magnetron sputtering at varying deposition temperatures to achieve different degrees of atomic order within the films. After a capping layer of Al or Cr was deposited to prevent oxidation, the samples were analyzed by NMR measurements at IFW Dresden. The XMLD measurements were performed using the XAS apparatus installed at the UE56-1/SGM beamline (Jülich). The results show clear and uniform features. However, the samples capped with Al show similar behavior to results for $Co_2FeAl_{0.5}Si_{0.5}$. Thus it is presumed that Al atoms are being implanted into the subsurface of Co_2FeSi, which makes Cr the capping layer of choice. Finally we see a change of the magnitude within the XMLD spectra depending on the local atomic order of the film.

We acknowledge support by DFG research group ASPIMATT.

[1] M. Kallmayer et al., Phy. Rev. B 84, 054448 (2011)

MA 25.7 Wed 11:00 H10

Spin-wave instabilities in a micro-structured $Co_2Mn_{0.6}Fe_{0.4}Si$ Heusler waveguide — •Philipp Pirro[1], Thomas Sebastian[1,2], Thomas Brächer[1,2], Alexander A. Serga[1], Takahide Kubota[3], Hiroshi Naganuma[4], Mikihiko Oogane[4], Yasuo Ando[4], 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, 67663 Kaiserslautern, Germany — [3]WPI Advanced Institute for Materials Research, Tohoku University, Katahira 2-1-1, Aoba-ku, Sendai 980-8577, Japan — [4]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Aoba-yama 6-6-05, Sendai 980-8579, Japan

Magnetic Heusler compounds are expected to show novel nonlinear magnonic transport phenomena due to very low Gilbert damping and high decay length for spin-waves [1] for some of these materials.

We present a nonlinear instability of propagating spin waves in the Heusler compound $Co_2Mn_{0.6}Fe_{0.4}Si$ which couples the initial spin wave (frequency f_{MW}) with two modes of different frequencies f_1 and f_2. As the separation $\Delta f = f_{MW} - f_1$ can reach more than 4 GHz, automodulation effects can be excluded and we interpret our observations as a kinetic instability.

We acknowledge support by the OPTIMAS Carl-Zeiss doctoral program, the DFG Research Unit 1464 and the Strategic Japanese-German Joint Research from JST: ASPIMATT.

[1] T. Sebastian, et al., Appl. Phys. Lett. 100, 112402 (2012).

MA 25.8 Wed 11:15 H10

NMR Sheds Light on Structural Evolution upon Annealing and Off-Stoichiometry in Nominal Co_2MnSi Thin Films — •Steven Rodan[1], Alexey Alfonsov[1], Maria-Eleni Belesi[1], Filippo Ferraro[2], Jürgen T. Kohlhepp[2], Henk J. M. Swagten[2], Bert Koopmans[2], Bernd Büchner[1], and Sabine Wurmehl[1] — [1]Leibniz Institute for Solid State and Materials Research, 01171 Dresden, Germany — [2]Eindhoven University of Technology, 5600 MB Eindhoven, Netherlands

Half-metallic ferromagnets (HMFs), with fully spin-polarized conduction electrons, are prime candidates for developing spintronic devices. Many Heusler compounds, such as Co_2MnSi, are predicted to be HMFs. A local probe technique such as nuclear magnetic resonance (NMR) is essential for understanding the microscopic origin of manifested physical properties, such as the magnetoresistance ratio measured in giant magnetoresistance (GMR) devices. Using NMR we have studied the evolution of local atomic structure in numerous Co_2MnSi thin films prepared by different methods, subjected to various annealing temperatures, and with varying stoichiometry. For all cases, we investigated models for different types of disorder, and quantitatively de-

duced the off-stoichiometry. By understanding how the local structure affects the physical properties, one can hope to control and optimize the properties which are of interest for spintronics by appropriately tuning the structure.

MA 25.9 Wed 11:30 H10

Cubic phase in Fe_2-based Heusler materials stabilized by disorder. — •Janos Kiss[1], Stanislav Chadov[1], Gerhard H. Fecher[1], Teuta Gasi[2], Vadim Ksenofontov[2], Peter Adler[1], and Claudia Felser[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden — [2]Johannes-Gutenberg Universität, Mainz

Due to their relatively large magnetic moments and strong magnetic anisotropy, the Fe_2-based Heusler compounds with tetragonal distortion are expected to be attractive candidates in hard-magnetic applications. In contrast to the first theoretical predictions, however, many of them crystallize in the cubic structure. In the framework of *ab-initio* electron structure calculations, we explain the stability of their cubic phase as based on combined effect of intrinsic chemical disorder and crystal symmetry.

MA 25.10 Wed 11:45 H10

Giant non-collinear magnetism and a spin reorientation in Mn_2RhSn Heusler compound. — •Olga Meshcheriakova[1,2], Ajaya K. Nayak[3], Stanislav Chadov[3], Jürgen Kübler[4], Teuta Gasi[1], Vadim Ksenofontov[1], Walter Schnelle[3], Alexander Tsirlin[3], and Claudia Felser[1,2,3] — [1]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg Universität Mainz, 55099 Mainz, Germany — [2]Graduate School of Excellence Materials Science in Mainz, 55128 Mainz, Germany — [3]Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden, Germany — [4]Institut für Festkörperphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany

Magnetic, structural, heat and transport properties of the bulk polycrystalline Mn_2RhSn tetragonal Heusler compound have been investigated. A field-driven magnetic transition was observed within a temperature range between 50 and 100 K. Such behavior was attributed to the non-collinear magnetism which results as competition between the anisotropy induced by tetragonal strain and typical antiparallel alignment of two Mn magnetic sublattices. According to the additional first-principles calculations, the present material exhibits a huge angle between these two magnetic sublattices. The experimentally measured saturated magnetization (of 2 μ_B per formula unit) was reasonably explained by combining the non-collinear magnetic calculations with the effects of an antisite disorder indicated by Moessbauer measurements.

This work is supported by the Graduate School of Excellence Materials Science in Mainz (MAINZ).

MA 25.11 Wed 12:00 H10

Different stacking of square layers in tetragonal Heusler compounds (Mn_3X, X=Ga, Ge, Sn) with perpendicular magnetization — •S.-C. Wu, G. H. Fecher, and C. Felser — Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Tetragonal Mn_3X (X=Ga, Ge, Sn) compounds attracted attention because of the perpendicular magnetization in thin films. The tetragonal Heusler structure can be built by stacking of square layers. The type of stacking maybe controlled by the conditions at the thin film growth. The most interesting property of binary Heusler alloys Mn_3X with tetragonal structure is the magneto-crystalline anisotropy (MCA). Consider layers as follows: A contains Mn and X, in A' the positions of Mn and X are exchanged, and B contains only Mn. The tetragonal Heusler type binaries (Al_3Ti-type) are build by ABA'B stacking of square layers, whilst ABAB stacking results in the $CuTi_3$-type structure. Calculations were performed for both type of structures. The perpendicular magneto-crystalline anisotropy in the $CuTi_3$ structure was found to be E_{MCA} = 0.82, 0.95, 1.22 meV for Mn_3Ga, Mn_3Ge, Mn_3Sn. Those values make them promising MCA materials. Furthermore, we report crystalline, electronic, and magnetic structure as well as elastic properties of the compounds.

MA 25.12 Wed 12:15 H10

Magnetic properties of Heusler nanocrystals inside carbon nanotubes — •Markus Gellesch, Maria Dimitrakopoulou, Maik Scholz, Sabine Wurmehl, Silke Hampel, and Bernd Büchner — Leibniz Institut für Festkörper- und Werkstoffforschung Dresden

Magnetic properties of nanoscale systems may differ largely from the magnetism in the respective bulk phase and thus can lead to the emergence of interesting and also novel physical properties. Here we present results of investigations of thermomagnetic properties of Heusler nanoparticles prepared inside multi-walled carbon nanotubes via a wet-chemical approach. We observe chemical stable Co_2FeGa nanoparticles with a narrow diameter distribution, a high degree of crystallinity and with a well-defined stoichiometry within the experimental error. Our study shows, that the coercive field of the Heusler nanocrystals inside carbon nanotubes is greatly enhanced and depends on the mean diameter of the Heusler nanocrystals, while the saturation magnetic moment known from the bulk phase is preserved. The results of our work open the door for the exploration of Heusler materials at the nanoscale and also guide the way to the synthesis of nano materials with tailored physical properties.

MA 26: Magnetic Thin Films I of 2

Time: Wednesday 9:30–12:15 Location: H3

MA 26.1 Wed 9:30 H3

Study of magnetization reversal in laterally patterned and continuous thin films via AC-Polarized neutron reflectometry. — •Dmitry Gorkov, Kirill Zhernenkov, Boris Toperverg, and Hartmut Zabel — Institute for Experimental Condensed Matter Physics, Ruhr University Bochum, 44780 Bochum, Germany

Among a number of techniques applied to study magnetization reversal processes in micro- and nanostructures, Polarized Neutron Reflectometry (PNR) is recognized as a unique and powerful tool providing access to depth and laterally resolved magnetization profile. Here we report on further advances of PNR being employed to retrieve information on the magnetization vector time evolution under AC magnetic field. We will show that PNR provides a possibility to distinguish between magnetization reversal driven by the domain wall (DW) nucleation, propagation and annihilation, and coherent magnetization rotation. We argue that additional information on lateral domain formation in individual patterned islands, as well as on magnetization correlations between different islands, can be obtained from off-specular scattering collected simultaneously with specular reflectivity. AC PNR studies were conducted on a set of continues Py films and those laterally patterned into periodic stripe arrays subjected to AC magnetic filed with frequencies up to 1.2 MHz and amplitudes up to 120 Oe. Measurements were carried out with a newly developed AC-PNR set up implemented on the Super ADAM reflectometer at the ILL, France [1,2]. Experimental results on domain kinetics under AC fields will be thoroughly discussed within the frameworks of current theoretical models.

MA 26.2 Wed 9:45 H3

Stretchable Magnetoelectronics for Smart Skin Applications — •Michael Melzer[1], Denys Makarov[1], and Oliver G. Schmidt[1,2] — [1]Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [2]Material Systems for Nanoelectronics, Chemnitz University of Technology, Reichenhainer Straße 70, 90107 Chemnitz, Germany

Realization of smart skins and interactive textiles fully relies on the development of flexible and stretchable electronics. Ideally, all components should be elastic and withstand many cycles of deformations without degrading in performance.

In this work, we introduce the world's first elastically stretchable spin valves [1], that outperform classical elements relying on giant magnetoresistive multilayers in terms of sensitivity (0.8% /Oe at 12 Oe), stretchability (up to 29%) and cyclic loading stability (>500 cycles). Their superior performance relies on the combination of random wrinkling and a unique periodic fracture mechanism, that introduces a highly stretchable meander-like structure into the functional magnetic nanomembranes. The possibility of a direct transfer of magnetic sensorics from rigid supports to soft membranes will be in the scope of the presentation. This renders magnetoelectronics to be fully integrated into stretchable electronics systems to equip them with magnetic func-

tionalities. The work was supported in part by the German federal ministry of education and research (project Nanett; FKZ: 03IS2011).

[1] M. Melzer et al., Adv. Mat. DOI: 10.1002/adma.201201898 (2012).

MA 26.3 Wed 10:00 H3

Pattern formation in the dipolar Ising model on a two-dimensional honeycomb lattice — •Robert Rüger and Roser Valentí — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt am Main, Germany

The two-dimensional Ising model with ferromagnetic nearest-neighbor interactions and long-range antiferromagnetic interactions is probably the simplest model system for the formation of magnetic domains. We present Monte Carlo simulation results for such a system on the honeycomb lattice and compare those to the known case of the square lattice in order to investigate the underlying lattice's influence on the formation of magnetic domain patterns. To deal with the long-range nature of the dipolar interaction we also present a simple method of evaluating effective interaction coefficients, which can be regarded as a more straightforward alternative to the prevalent Ewald summation techniques.

MA 26.4 Wed 10:15 H3

La_2CrWO_6: A Possible Antiferromagnet Half-Metal — •Mehran Vafaee, Mehrdad Baghaie Yazdi, Vikas Shabadi, Philipp Komissinskiy, and Lambert Alff — Institute of Materials Science, Technische Universität Darmstadt, Petersenstr. 23, 64287 Darmstadt, Germany

Half-metallic antiferromagnets, materials with zero net magnetization and 100% spin polarization of charge carriers, are promising for spintronic applications, but have never been synthesized up to now. La_2CrWO_6 with d^3-d^3 configuration has been suggested as a strong candidate based on density functional theory [1]. However, due to the unusual valence state of W^{3+}, this material is thermodynamically unstable. For the first time, we report the thin film synthesis of La_2CrWO_6 by pulsed laser deposition. X-ray absorption spectroscopy at the Cr K-edge and W $L_{2,3}$-edges show +3 valence state for Cr and a mixed valence state of $+3\,/\,+5$ for W. X-ray linear dichroism confirms undistorted Cr octahedra symmetry. The magnetization shows *ferri*magnetic instead of antiferromagnetic behavior. X-ray magnetic dichroism measurements indicate that antisite disorder is responsible for the reduced W magnetic moment. Thus, suppression of antisite disorder is an important strategy to obtain half-metallic antiferromagnets in double perovskites.

[1] V. Pardo and W. E. Pickett, Phys. Rev. B **80**, 054415 (2009).

MA 26.5 Wed 10:30 H3

Magnetic properties of Fe_xMn_{1-x}/Ni bilayers: an ab initio study — •Svitlana Polesya[1], Sergiy Mankovsky[1], Hubert Ebert[1], Wolfgang Kuch[2], and Jan Minar[1] — [1]Universität München, Department Chemie, Butenandtstr. 5-13, D-81377 München, Germany — [2]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

The TB-KKR Green's function method is used for an ab initio investigation of thin antiferromagnetic Fe_xMn_{1-x} films deposited on a ferromagnetic (FM) Ni substrate. The calculations were performed for the Fe concentration x from 40 to 60 %. It is shown that the ground state magnetic structure of Fe_xMn_{1-x} films on FM Ni depends weakly on the concentration x but is modified essentially upon the change of the film thickness. Using the exchange coupling parameters evaluated on the basis of the selfconsistent electronic structure, the Neél temperature (T_N) of the Fe_xMn_{1-x} films is calculated by means of Monte Carlo simulations. In good agreement with experiment[1] T_N increases with increasing film thickness but exibits a much weaker dependence on the concentration x. The influence of the in-plane and out-of-plane magnetization direction of FM Ni on the magnetic structure and T_N of Fe_xMn_{1-x} films is also discussed.

[1]. M. Stampe, P. Stoll, T. Homberg, K. Lenz, W. Kuch, PRB **81**, 104420 (2010).

15 min. break

MA 26.6 Wed 11:00 H3

High TMR ratio in Co_2FeSi and Fe_2CoSi based magnetic tunnel junctions — •Christian Sterwerf[1], Markus Meinert[1], Manuel Glas[1], Jan-Michael Schmalhorst[1], Günter Reiss[1], and Elke Arenholz[2] — [1]Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

Co and Fe based Heusler compounds are promising materials for spintronic applications, especially because of their high magnetic moments and their high Curie temperatures. More recently, inverse Heusler compounds such as Fe_2CoSi have been proposed as half-metallic electrode materials. [1]

Epitaxial $Co_{2-x}Fe_{1+x}Si$ thin films with x ranging from 0 to 1 were prepared by DC and RF magnetron co-sputtering on MgO (001) substrates. The crystallographic order and the transition from regular to the inverse Heusler compound Fe_2CoSi was investigated by x-ray diffraction. The films exhibit a high degree of structural order. Soft x-ray absorption, magnetic circular dichroism (XMCD) and ferromagnetic resonance (FMR) measurements were performed to determine the magnetic properties.

Magnetic tunnel junctions with MgO tunneling barrier and CoFe counter electrode exhibit TMR ratios ranging up to 159% at room temperature.

[1] Luo *et al.*, JPD 40, 7121 (2007)

MA 26.7 Wed 11:15 H3

Stoichiometric variations of $[La_{2/3}Sr_{1/3}]_{n\pm1}Mn_nO_{3n\pm1}$/$SrTiO_3$ — •Alexandra Steffen[1], Sabine Pütter[1], Jürgen Schubert[3], Stefan Mattauch[1], and Thomas Brückel[1,2] — [1]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at FRM II, Lichtenbergstr. 1, 85747 Garching — [2]Jülich Centre for Neutron Science JCNS und Peter Grünberg Institut PGI, JCNS-2, PGI-4: Scattering Methods, Forschungszentrum Jülich GmbH, 52425 Jülich — [3]Peter Grünberg Institut PGI, PGI-9: Semiconductor Nanoelectronics, Forschungszentrum Jülich GmbH, 52425 Jülich

Transition metal oxide thin films show a huge variety of fascinating phenomena like ferromagnetism at interfaces of non-magnetic materials as found in $SrTiO_3$/$KTaO_3$[1]. By oxide Molecular Beam Epitaxy we achieve high quality epitaxial films with exact composition control. Here, we compare single layers of $[La_{2/3}Sr_{1/3}]_1Mn_1O_3$, $[La_{2/3}Sr_{1/3}]_2Mn_3O_8$ and $[La_{2/3}Sr_{1/3}]_3Mn_2O_7$ on $SrTiO_3$. The stoichiometry was adjusted in-situ via quarz-crystal balance and cross-checked with RBS while the growth mode was monitored via RHEED. By LEED, XRR and XRD, the crystalline sample quality was studied. The magnetic properties were determined via SQUID. We report investigations of the depth-dependent distribution of magnetic moments in these layers via neutron reflectometry. At TREFF@FRM II we quantified the thickness of the magnetic dead layer[2,3] at the interface.

[1] R. Oja et al., Phys. Rev. Lett. 109, 127207 (2012) [2] M. Angeloni et a., J. Appl. Phys. 96, 6387 (2004) [3] M. Huijben et al., Phys. Rev. B, 78, 094413 (2008)

MA 26.8 Wed 11:30 H3

Out-of-plane vectorial magnetometry on a thin $(CoFe)_{77}Tb_{23}$ film investigated by a new multichromatic dual-beam magnetometer based on the magnetooptic Kerr effect — •Timo Kuschel, Gerhard Götz, Zoe Kugler, and Günter Reiss — University of Bielefeld, Germany

Magnetic thin films with out-of-plane (OOP) magnetic easy axis are key components for spintronic devices like magnetic tunnel junctions which use OOP magnetization. Current investigations focus on thin $(CoFe)_{1-x}Tb_x$ films which are partially preferred OOP magnetized.

In order to illustrate the OOP reversal process of the magnetization in such magnetic systems a detailed vectorial magnetometry study is performed on an exemplary $(CoFe)_{77}Tb_{23}$ film. A new home-built multichromatic dual-beam magnetometer is used for the measurements based on the magnetooptic Kerr effect. The components of the magnetization vector during the reversal process can be determined using s- and p-polarized incident light and varied azimuthal sample alignment with respect to the plane of incidence of light.

The results show a monodomain remanent state which is not completely OOP aligned. The observed details of the reversal process reveal a coherent rotation of the magnetization from OOP alignment (0°) in magnetic saturation to more than 45° tilting for small reversed OOP magnetic field strength. During the magnetic switching the magnetic moment of the film is decreased down to less than 25% due to domain splitting. Afterwards, the monodomain state is reached again

and the magnetization rotates coherently into reversed OOP direction.

MA 26.9 Wed 11:45 H3

Influence of spin disorder on the relation between magnetic anisotropy and orbital magnetism. — •Leonid Sandratskii — Max-Planck-Institut für Mikrostrukturphysik Weinberg 2, D-06120 Halle, Germany

The close relation between the magnetic anisotropy and the anisotropy of the orbital moments is widely accepted. On the other hand, the question, how the temperature-induced spin-disorder influence the relation between magnetic anisotropy and orbital magnetism remains unknown. Using first-principles approach that takes into account both spin disordering and spin-orbit coupling we obtain principally different behavior of orbital magnetism and magnetic anisotropy for different films. While the magnetic anisotropy of the Co film tends to decrease with spin disordering, in the Fe film an opposite trend to an increase of the magnetic anisotropy is obtained. In FePt film we obtain complex interplay of the orbital and spin magnetism leading to the orthogonality of the spin and orbital moments of the Fe atoms at certain level of spin disorder. We explain the variety of behavior by different response of the electronic structure to the spin disordering and relate it to the variety of the experimentally detected temperature dependences of the magnetic anisotropy in thin films.

MA 26.10 Wed 12:00 H3

Epitaxial $DyCo_5$ thin films with magnetic compensation — •Benjamin Schleicher, Marietta Seifert, Ludwig Schultz, and Volker Neu — IFW Dresden, Institute for Metallic Materials, Dpt. Magnetic Microstructures, Helmholtzstr. 20, D-01069 Dresden

Epitaxial $DyCo_5$ thin films with a thickness of 50 nm were prepared by pulsed laser deposition from elementary targets in an UHV environment. The use of Cr-buffered MgO (110) and Ru-buffered Al_2O_3 (0001) substrates results in an in-plane and out-of-plane growth of the unit cells' crystallographic c-axis, respectively. The structural properties were investigated with XRD and texture measurements and the (1:5)-phase was confirmed through the successful verification of the appropriate XRD-peaks and pole figures. Subsequently, magnetization has been measured as a function of temperature with a 9 T vibrating sample magnetometer in a temperature range from 20 K to 400 K. Additionally, hysteresis loops were measured at discrete temperatures and different field angles with respect to the crystals c-axis to probe the anisotropic behavior of the samples.

The ferrimagnetic coupling between the heavy rare earth Dy and the transition metal Co was confirmed by identifying a minimum of the magnetization (and thereby of the magnetic moment) of the sample at a certain temperature (compensation point), and the value of roughly 110 K is in qualitative agreement with literature data of single crystals. In addition to that, a spin reorientation transition from easy axis via easy cone to easy plane was observed in a temperature range of 250 - 400 K.

MA 27: Magnetic Thin Films II of 2

Time: Wednesday 15:00–17:45 Location: H3

MA 27.1 Wed 15:00 H3

Dynamics of a magnetic bubble in thin films with perpendicular anisotropy — •B. Krüger[1], F. Büttner[1,2], C. Moutafis[3], M. Schneider[2], C. Günther[2], J. Geilhufe[4], J. Mohanty[2], C. v. Korff Schmiesing[2], J. Franken[5], M. Foerster[1], T. Schulz[1], C. Vaz[3], H. Swagten[5], S. Eisebitt[2,4], and M. Kläui[1] — [1]Uni Mainz, Germany — [2]TU Berlin, Germany — [3]PSI, Villigen, Switzerland — [4]HZB, Berlin, Germany — [5]TU Eindhoven, Netherlands

Magnetic bubbles are circular bi-domain states in perpendicular magnetic thin films. The magnetization structure with the curling in-plane domain wall defines a topology, which determines the equation of motion. It was predicted that the lowest lying eigenmode motion is not circular [1], in contrast to observations on magnetic vortices, which are the in-plane analogous of bubbles. These differences can be explained by a recent analytical model[2], which describes the displacement of the bubble by two waves that travel along the domain wall at different speeds and in opposite directions. This results in an effective mass of the bubble, whereas the vortex is described as a massless particle.

Using X-ray holographic imaging, we image the gyration of a bubble and we present the experimental determination of the trajectory. We demonstrate the good agreement with our theoretical model, allowing us to determine the eigenfrequencies and the effective mass of the bubble domain.

[1] C. Moutafis et al., PRB 79, 224429 (2009).
[2] I. Makhfudz et al., PRL 109, 217201 (2012).

MA 27.2 Wed 15:15 H3

Magnetic domain walls and thermally-excited spin waves in single-chain magnets and ferromagnetic thin films — •Alessandro Vindigni[1], Thomas T. Micheals[1], Boris Sangiorgio[1], Orlando V. Billoni[2], Rodolphe Clérac[3], Hitoshi Miyasaka[4], Niculin Saratz[1], Urs Ramsperger[1], and Danilo Pescia[1] — [1]Laboratory for Solid State Physics, ETH Zurich, Switzerland — [2]Facultad de Matematica, Astronomia y Fisica, Universidad National de Cordoba (AR) — [3]CNRS, Centre de Recherche Paul Pascal (CRPP), Pessac, France — [4]Graduate School of Natural Science and Technology, Kanazawa University, Japan

Several properties of magnetic materials are determined by domain-walls (DWs) and their structure. In many fundamental and applicative contexts, modeling a DW with a (Walker) profile which solely depends on one spatial variable suffices to capture the essential physics. Though somewhat forgotten, it has been known since the eighties that spin waves propagating through such a DW are expected to acquire a phase shift. Besides those traveling waves, an additional eigenmode of the linearized Landau-Lifshitz equation is a "bound state", localized right at the DW center. These distinctive features make spin-wave renormalization act differently in the presence of DWs with respect to the standard case in which the magnetization is assumed to be spatially homogeneous. The two alternative treatments yield different predictions, which are discussed in relationship with experiments on molecular spin chains and ultra-thin magnetic films.

MA 27.3 Wed 15:30 H3

Longitudinal transport properties of Fe films on GaAs(001) — •S Wimmer[1], S Bornemann[1], D Ködderitzsch[1], J Minár[1], T Hupfauer[2], D Weiss[2], and H Ebert[1] — [1]Department Chemie, Ludwig-Maximilians-Universität München — [2]Department Physik, Universität Regensburg

We have applied the fully relativistic spin-polarized Korringa-Kohn-Rostoker method to investigate the longitudinal transport properties of Fe layers on GaAs(001) substrates. Our theoretical approach is based on the linear response Kubo formalism that allows to introduce a layer-resolved conductivity σ^{IJ} for two-dimensional systems [1] and that has been extended to the fully relativistic case. For the Fe_n/GaAs(001) metal/semiconductor surface system our results qualitatively reproduce the experimentally observed in-plane anisotropy (IPA) of the resistivity which is caused by the the low symmetry of the underlying surface. Our results demonstrate in particular that the anisotropic magnetoresistance (AMR) as well as the surface induced IPA are sensitive to the substrate termination and thickness of the Fe overlayer.

[1] W.H. Butler, et al. *Phys. Rev. B* **52**, 13399 (1995)

MA 27.4 Wed 15:45 H3

Magneto-crystalline anisotropy detected by X-ray magnetic linear dichroism at the 3p edge of Fe: First experiments and theory — •Marc Tesch[1], Markus Gilbert[1], Hans-Christoph Mertins[1], Andreas Gaupp[2], Dominik Legut[3], Peter Oppeneer[4], Daniel Bürgler[5], and Claus Schneider[5,6] — [1]FH Münster, Stegerwaldstr. 39, D-48565 Steinfurt — [2]HZB, Albert Einstein Str. 15, D-12489 Berlin — [3]Nanotechnology Centre, Ostrava, Czech Republic — [4]Depart. of Physics, Uppsala Uni., Box 530, S-751 21 Uppsala, Sweden — [5]FZ Jülich GmbH, PGI-6, D-52425 Jülich — [6]Fakultät f. Physik and CeNIDE, Uni Duisburg-Essen, D-47048 Duisburg

We present first experimental results of magneto-crystalline anisotropy detected on single crystalline bcc Fe films at the 3p edge by X-ray magnetic linear dichroism (XMLD) measurements using linearly polarized

undulator radiation at BESSY. We found a strong dependence of the XMLD signal on the orientation of the crystal axes, i.e. the magnetic hard and easy axes, with respect to the polarization vector of the light. The extension of measurements of the magneto-crystalline anisotropy from the 2p to the 3p edge completes the understanding of underlying effects, in particular concerning the role of the exchange splitting. While it can often be neglected in calculations for the 2p edge with large spin-orbit splitting it must be considered at the 3p edge, where exchange splitting and spin-orbit splitting are of the same order of magnitude. The experimental results are compared with our ab initio calculations to distinguish between competing models of the electronic band structure.

MA 27.5 Wed 16:00 H3

Investigation of induced Pt magnetic polarization in $Pt/Y_3Fe_5O_{12}$ bilayers — •Sibylle Meyer[1], Stephan Geprägs[1], Matthias Opel[1], Stephan Altmannshofer[1], Fabrice Wilhelm[2], Andrei Rogalev[2], Rudolf Gross[1,3], and Sebastian T. B. Goennenwein[1] — [1]Walther Meißner Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]European Synchrotron Research Facility (ESRF), Grenoble, France — [3]Physik-Department, Technische Universität München, Garching, Germany

The detection of spin currents is often based on the interconversion of spin and charge currents in a metallic Pt layer, taking advantage of the inverse spin Hall effect. However, for an unambiguous interpretation the presence of a static magnetic proximity effect, as it is well established in ferromagnetic metal/Pt heterostructures, has to be taken into account. So far, no information on such a proximity effect is available for ferromagnetic insulator/Pt heterostructures. Using X-ray magnetic circular dichroism (XMCD) measurements, we explore the possible existence of induced magnetic moments in thin Pt films deposited onto the ferrimagnetic insulator $Y_3Fe_5O_{12}$. Our data shows that if present at all, the induced moment in Pt is small. Integrating the XMCD signal allows to estimate an upper limit for the induced Pt magnetic polarization of $(0.003 \pm 0.001)\,\mu_B$ per Pt atom [1]. This work was supported by the ESRF via HE-3784, by the DFG via SPP 1538, and the German Excellence Initiative via NIM.

[1] S. Geprägs *et al.*, Appl. Phys. Lett., submitted (2012); arXiv:1211.0916.

15 min. break

MA 27.6 Wed 16:30 H3

Magnetization profile across bcc Fe films as seen by x-ray resonant magnetic reflectivity — •Emmanuelle Jal[1], Jean-Marc Tonnerre[1], Maciej Dabrowski[2], Marek Przybylski[2,3], and Jürgen Kirschner[2,4] — [1]Institut Néel, CNRS and UJF, Grenoble, France — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [3]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [4]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

Any modification in electronic states occupation and lower atomic coordination at the surface/interface resulting in band narrowing changes the surface magnetic moment. Since the magnetometric methods are integral and feature no spatial resolution, they cannot be used for local investigations. However, the magnetic moment can be taken as a parameter influencing diffraction or reflectivity that can be either probed with neutrons or polarized x-ray at the absorption edge. Therefore, we investigate the Au/Fe(13.5 and 5.9ML)/Ag(1,1,6) as well as on Au/Fe(13ML)/Ag(001), by soft x-ray resonant magnetic reflectivity (SXRMR) at the Fe L3 edge. At T=20K we observe 30% enhancement of the Fe magnetic moment with respect to the bulk value, located within 2-3ML of Fe (the spatial resolution of our method) at both Au/Fe and Fe/Ag interfaces. This increase in the very interface region is in agreement with theoretical findings. The comparison of the calculated value averaged for the first three layers is in a good agreement with 2.7μB, observed in our experiment.

MA 27.7 Wed 16:45 H3

Straining epitaxial Fe-Co thin films to increase magnetocrystalline anisotropy — •Ludwig Reichel[1,2], Sandra Kauffmann-Weiss[1,2], Ludwig Schultz[1,2], and Sebastian Fähler[1] — [1]IFW Dresden, PF 270116, 01171 Dresden — [2]TU Dresden, 01062 Dresden

The demand on permanent magnets is strongly increasing and alternatives to the common rare-earth based alloys lack. Fe-Co alloy is a promising candidate as it provides already a very high magnetic moment. High magnetocrystalline anisotropy is expected when its equilibrium cubic unit cell is strained tetragonally with $(c/a)_{bct}$ around 1.2 [1,2].

In the present investigation, epitaxial Fe-Co films between 1 and 10 nm thickness were deposited at room temperature using pulsed laser or magnetron sputtering deposition. Different buffer layers were used to provide the required in-plane lattice parameter a. As the unit cell volume should remain constant, the out-of-plane lattice parameter c is expected to adapt accordingly. In situ diffraction of high energetic electrons (RHEED) during film growth allows us to monitor the epitaxial growth and the relaxation of strain which begins at a critical film thickness d_C. Out-of-plane magnetic hysteresis measurements exploiting the anomalous Hall effect are compared with the in situ results. Both methods show that the critical thickness does not exceed few nanometers for the described approach.

[1] Burkert et al. Phys. Rev. Let. 93 (2004) 027203

[2] Neise et al. Phys. Status Solidi B 248 (2011) 2398

This work is funded by the European Union through REFREEPERMAG-FP7.

MA 27.8 Wed 17:00 H3

Symmetric magnetization reversal in polycrystalline exchange coupled systems — •Amitesh Paul[1], Neelima Paul[2], Arno Ehresmann[3], Stefan Mattauch[4], and Peter Böni[1] — [1]Technische Universität München, Physik Department E21,James-Franck-Strasse, D-85748 Garching b. München Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH,Hahn-Meitner-Platz 1, D-14109 Berlin, Germany — [3]Universität Kassel, Institut für Physik and CINSaT, Heinrich-Plett-Strasse 40, D-34132 Kassel, Germany — [4]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at FRM II, Lichtenbergstraße 1, 85747, Garching, Germany

Training in exchange bias systems plays an essential role in understanding the very origin of the biasing effect. The nonequilibrium arrangement of antiferromagnetic (AF) spins at the antiferromagnetic-ferromagnetic interface, related to the AF uniaxial anisotropy, plays a crucial role during the initial training. Our system of choice,IrMn/CoFe, possesses softer uniaxial anisotropy compared to other AF systems (e.g., CoO), thereby reducing the energy penalty due to nonequilibrium spins. Different methods have been applied to initialize or modify the unidirectional anisotropy. Magnetization reversal mechanisms were investigated during the first two field cycles to identify the role of each method on the training. A detailed analysis of polarized neutron scattering using the distorted wave Born approximation reveals a simultaneous process of domain nucleation and coherent rotation for magnetization reversal.

MA 27.9 Wed 17:15 H3

Influence of keV-He ion bombardment on the magnetic properties of Co/Pd multilayers — •Nicolas Müglich[1], Olav Hellwig[2], Oliver Buhl[1], Tanja Weis[1], Dieter Engel[1], and Arno Ehresmann[1] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Strasse 40, Kassel 34132, Germany — [2]San Jose Research Center, HGST, A Western Digital Company, 3403 Yerba Buena Road, San Jose, California 95135, USA

Thin films of ferromagnetic Co separated by Pd films with thicknesses in the first ferromagnetic maximum of interlayer exchange coupling are magnetically dominated by perpendicular-to-plane anisotropy and labyrinth stripe domain patterns in remanence. During the magnetization reversal of such a multilayer system domain nucleation and domain wall movement can be observed for different external magnetic fields H. The influence of keV-He ion bombardment on the microstructure of the system and its resultant decrease of magnetic anisotropy has been investigated by vibrating sample magnetometry, polar magneto-optical Kerr effect and magnetic force microscopy. It is shown that areas of ferromagnetic in-plane anisotropy are created due to the ion bombardement and that the system shows an increasing quotient of superparamagnetism in the deeper layers of the multilayersystem.

MA 27.10 Wed 17:30 H3

Quantum well states in Cu and oscillatory magnetic anisotropy in Cu/Fe and Cu/Co bilayers — •Sujit Manna[1], Pedro L. Gastelois[1,2], Maciej Dabrowski[1], Piotr Kuświk[1], Marek Cinal[3], Marek Przybylski[1,4], and Jürgen Kirschner[1,5] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

— [2]Centro de Desenvolvimento da Tecnologia Nuclear, Belo Horizonte, Brazil — [3]Institute of Physical Chemistry of the Polish Academy of Sciences, Warszawa, Poland — [4]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [5]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

From our previous experiments it is obvious that the strong effect of quantum well states (QWS) formed by d-electrons on magnetic anisotropy (MA) of Fe and Co films exists at low temperature only. In case of nonmagnetic/ferromagnetic bilayers one can expect changes of MA due to the QWS formed in the nonmagnetic cover layer. In an extension of the previously reported experiment [1], we were able to observe oscillatory magnetic anisotropy of large amplitude at T=5K for both Co and Fe films due to QWS formed in the Cu overlayer. We explain such quantum oscillation of MA as originating from d-QWS formed in Fe and/or Co, but hybridized to the sp-QWS formed in the Cu film and penetrating to the Fe and/or Co films. The period of MA oscillations for Cu/Fe is found to be independent of the Fe film thickness, in agreement with our theoretical predictions. [1] Ch. Würsch et al., Nature 389, 937 (1997).

MA 28: Magnetic Materials

Time: Wednesday 15:00–18:00 Location: H22

MA 28.1 Wed 15:00 H22

Electronic Structure Calculations of Materials with Increased Magnetic Anisotropy Energies — •Alexander Edström, Olle Eriksson, and Jan Rusz — Uppsala University, Department of Physics and Astronomy, Division of Materials Theory, Uppsala, Sweden

Materials with a high saturation magnetization, as well as high magnetic anisotropy energy, are required to produce permanent magnets which are important in a wide range of applications. Here DFT calculations are used to study magnetizations and magnetic anisotropy energies in a variety of materials. Certain materials such as FeCo based alloys, with relatively large saturation magnetization, are found to also exhibit high magnetic anisotropy energies at particular crystal distortions and alloy concentrations [1]. This makes them potentially useful for permanent magnet applications. We report first principles calculations of magnetization and magnetocrystalline anisotropy energy for a wide range of concentrations and deformations of the cubic and hexagonal lattices. This work was supported by ERC project RE-FREEPERMAG and Swedish Research Council.

1. T. Burkert, et al, PRL 93, 027203 (2004)

MA 28.2 Wed 15:15 H22

Magnetism and structural instability in frustrated intermetallic AFe_4X_2 systems — •Inga Kraft, Christoph Bergmann, Katharina Weber, Nandang Mufti, Christoph Geibel, and Helge Rosner — Max Planck Institute for Chemical Physics of Solids, Dresden

Frustration in intermetallic systems lead to an increase of quantum fluctuations and often result in unusual properties. Magnetic, thermodynamic, and structural data of the intermetallic AFe_4X_2 compounds (A=Sc,Y,Lu,Zr; X=Si,Ge) evidence that these compounds cover the whole regime from frustrated AFM order up to an AFM quantum critical point. In agreement with the experimental findings our DFT calculations yield an orthorhombic ground state and together with magnetic order a strong interplay of structure and magnetism. We discuss the influence of the A and X site atoms on the strength of magnetic interactions and the size of structural distortion.

MA 28.3 Wed 15:30 H22

Calculation of the angular dependence of XMLD in reflection in 3d transition metals at 3p edges — •Dominik Legut[1], Peter Oppeneer[2], Marc Tesch[3], Hans-Christoph Mertins[3], Markus Gilbert[3], and Andreas Gaupp[4] — [1]Nanotechnology Centre, Ostrava, Czech Republic — [2]Department of Physics and Astronomy, Uppsala, Sweden — [3]FH Münster, Steinfurt, Germany — [4]HZB, Berlin, Germany

The full angular dependence of the x-ray magnetic linear dichroism (XMLD) in reflection spectra on the crystalline orientation of the magnetization was investigated for ferromagnetic bcc Fe, fcc Ni and fcc Co. The anisotropic XMLD spectra were computed in the single electron picture within the framework of the DFT. The excitation stemming from semicore 3p levels were considered. The calculated results show similarities as well as differences between $L_{2,3}$ and $M_{2,3}$ edges, because of hybridization of two $3p_{1/2}$ sub-levels and four $3p_{3/2}$ sub-levels (m_j levels).[1] The XMLD signal is strongly dependent on the magnetization direction with respect to the crystal axes. Furthermore, the influence of the sample thickness on the reflection coefficients is investigated. The magnitude of the lattice distortion vs. the influence of the spin-orbit coupling on the reflection coefficients for general magnetization direction is revealed. The calculated data show very good agreement with recently recorded spectra of bcc Fe. The influence of the spin-orbit coupling and exchange interaction at 3p states is revealed.

References:
1. S. Valencia *et al.*,Phys. Rev. Lett. **104**, 187401 (2010).

MA 28.4 Wed 15:45 H22

Quadratic magneto-optical permittivity coefficiets in cubic Fe, Co, Ni calculated ab-initio — Jana Hamrlova, •Jaroslav Hamrle, Dominik Legut, Kamil Postava, and Jaromir Pistora — Nanotechnology Centre, VSB - Technical University of Ostrava, Czech Republic

Using ab-initio calculations, we determine spectra of the second-order magneto-optical permittivity coefficients (G_{44}, ΔG) for ferromagnetic bcc Fe, fcc Ni and fcc Co. Those second-order magneto-optical permittivity coefficients provide phenomenological description of all second-order magneto-transport effect, such as AMR, quadratic MOKE, XMLD, magneto-refracticity, etc. depending on the investigation technique and the energy of the probing photon (zero photon energy means dc). The calculations of the conductivity/permittivity tensor elements are done within the framework of DFT using general magnetic orientation with respect to the crystal axis. Then, dependence of the permittivity elements on general magnetization orientation is compared with expected dependences as provided by symmetry arguments.

MA 28.5 Wed 16:00 H22

First-pinciples calculations of Gilbert damping parameter for magnetic metals and alloys — •Sergiy Mankovsky, Diemo Koedderitzsch, and Hubert Ebert — Dept. Chemie, Universität München, Butenandtstr. 5-13, D-81377 München, Germany

The results of first-principles calculations of the elements of the Gilbert damping tensor, $\alpha_{\nu\nu}$, are presented. Calculations have been performed for various systems, e.g., pure 3d transition metals, magnetic alloy systems and magnetic semiconductors. The anisotropy of the Gilbert damping and its dependence on the orientation of the magnetization and structure parameters, have been analyzed. Furthermore, the role of chemical and temperature induced structural and magnetic disorder has been investigated. The corresponding scattering mechanisms have been accounted for by using the coherent potential approximation (CPA) alloy theory. The theoretical results for the Gilbert damping parameters are compared with available experimental data.

MA 28.6 Wed 16:15 H22

Partial substitution of Nd in FeNdB permanent magnets by economic rare earth metals — •Dagmar Goll[1], Ralf Löffler[1], Arne Huber[2], and Gerhard Schneider[1] — [1]Hochschule Aalen, Institut für Materialforschung, Aalen — [2]Robert Bosch GmbH, Gerlingen-Schillerhöhe

High-performance permanent magnets like Fe-Nd-B sintered magnets are very promising for high-power motor and generator applications in resource efficient mobility and renewable energy. However, the associated increasing demand for intermetallic rare earth (RE) and transition metal (TM) compounds recently gets somewhat abated due to the dependence on rare earth metal raw materials from China. Partial substitution of Nd by economic RE metals like Ce, La or Y may result in more cost-efficient magnets. To evaluate the optimum conditions for realizing cost-efficient high-performance magnets the intrinsic magnetic properties (anisotropy constant K_1, saturation polarization J_s)

of as-cast $Fe_{14}(Nd_{1-x}RE_x)_2B$ are determined from Kerr microscopy investigations and magnetometry measurements of the corresponding hysteresis loops *(project supported by BMBF).*

15 min. break

MA 28.7 Wed 16:45 H22

Ab initio study of thermodynamic, electronic, magnetic, structural, and elastic properties of Ni_4N allotropes — Pavlina Hemzalova[1,2,3], •Martin Friak[1,3,4], Mojmir Sob[2,3,4], Alexander Udyansky[1], Duancheng Ma[1], and Joerg Neugebauer[1] — [1]Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, Germany — [2]Masaryk University, Brno, Czech Republic — [3]Central European Institute of Technology, CEITEC MU, Brno, Czech Republic — [4]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic

We have used density functional theory calculations to study thermodynamic, structural, elastic, and electronic properties of Ni_4N, that forms e.g. when nitriding Ni-containing alloys, in eight different crystallographic phases. In agreement with the experimental findings, the cubic structure with Pearson symbol cP5, space group Pm-3m (221), is found to be the most stable. We determine structural parameters, internal degrees of freedom, bulk moduli and their pressure derivatives for all eight allotropes. The thermodynamic stability and bulk modulus is shown to be anti-correlated. Comparing ferromagnetic and nonmagnetic states, we find common features between the magnetism of elemental Ni and studied ferromagnetic Ni_4N structures. For cubic allotropes, we predict single-crystalline elastic constants, their area moduli, and homogenized polycrystalline elastic moduli. We demonstrate that the elastic anisotropy of the ground-state Ni_4N is qualitatively opposite to that in the elemental Ni. One of the studied metastable cubic phases is found auxetic, i.e. exhibiting negative Poisson ratio.

MA 28.8 Wed 17:00 H22

Contributions of domain wall substructures to the magnetization configurations — •Sukhvinder Singh, Haibin Gao, and Uwe Hartmann — Experimental Physics, Saarland University, P O. Box 151150, D-66041, Saarbrücken, Germany

Magnetic domain wall substructures have strong influences on domain wall behavior, i.e., movement and pining effects within an external magnetic field. In this work, contributions of domain wall substructures (Bloch lines, cross-tie wall components, vortex-antivortex pairs) and individual vortices to the magnetization configurations of EBL-patterned Permalloy thin films and Fe-whiskers have been investigated. MFM was employed to check the influence of those substructures' interactions with notches and sample edges with and without an in-plane static magnetic field. The result shows the attractive interaction between magnetic charges at the edge and the vortex-antivortex dipolar charges in the cross-tie wall. Stripe domains were observed for films of more than 100 nm of thickness. In contrast, well arranged stripe domains mixed with Landau domain pattern or cross-tie wall structures were found on thinner samples. OOMMF was used to model the behavior observed by MFM.

MA 28.9 Wed 17:15 H22

Spectroscopic study of the Kondo semiconductors CeM_2Al_{10} (M = Ru, Os and Fe) — •Fabio Strigari[1], Thomas Willers[1], Zhiwei Hu[2], Chang-Yang Kuo[2], Stefano Agrestini[2], Andrea Severing[1], and Liu Hao Tjeng[2] — [1]Institute of Physics II, University of Cologne — [2]MPI for Chemical Physics of Solids, Dresden

The orthorhombic CeM_2Al_{10} compounds with M = Ru, Os, and Fe belong to a fairly new family of Ce Kondo semiconductors, which exhibit a novel magnetic phase transition at $T_0 = 27\,K$ (M = Ru) and 29 K (M = Os). The ordering mechanism is still a matter of debate since the ordering temperature is unexpectedly high and the ordered moment strongly reduced. The isostructural $CeFe_2Al_{10}$ lacks any phase transition and shows the highest degree of hybridization between $4f$ and conduction electrons within the family. For $CeRu_2Al_{10}$ and $CeOs_2Al_{10}$ the static magnetic susceptibility shows a strong anisotropy and Curie-Weiss behavior down to T_0 and 40 K, respectively, whereas for $CeFe_2Al_{10}$ it suggests more intermediate valent behavior. Due to the presence of the crystalline electric field, the $4f$ ground state wave functions are expected to be highly anisotropic and their knowledge is essential to understand the magnetic properties in this compounds.

We performed extensive experimental studies by means of x-ray based spectroscopic techniques – namely soft x-ray absorption, resonant inelastic x-ray scattering and hard x-ray photoemission spectroscopy – in order to determine the crystal-field ground state and quantitatively analyze the $4f$ valence for the members of the 1-2-10 family.

MA 28.10 Wed 17:30 H22

Nature of local moments in La(Sr)CoO3 — •Jan Kunes and Vlastimil Krapek — Institute of Physics, AS CR, Prague, Czechia

We present a numerical study of magnetic properties of LaCoO3 and SrCoO3 using the dynamical mean-field theory. In particular, we investigate the origin of the local magnetic moments (Curie susceptibility). Using the decomposition of the temporal spin-spin correlation functions into contributions from atomic multiplets we generalize the notion of atomic multiplets to situations with the strong covalent bonding. We show that the magnitude of the local moment is in general not a good parameter to identify the microscopic atomic states underlying the formation of local magnetic moments. Our numerical results exclude the so called intermediate spin states to play an important role in magnetism of LaCoO3.

MA 28.11 Wed 17:45 H22

Investigation on magnetoacoustic properties of spin-ice materials Dy2Ti2O7 and Ho2Ti2O7 — •Salim Erfanifam[1], Sergei Zherlitsyn[1], Joachim Wosnitza[1], Roderich Moessner[2], Andrei Anatolievich Zvyagin[2,3], Paul McClarty[2], Oleg Petrenko[4], and Geetha Balakrishnan[4] — [1]Hochfeld-Magnetlabor Dresden, Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden, Germany — [2]Max-Planck Institut für Physik komplexer Systeme, D-01187 Dresden, Germany — [3]B.I. Verkin Institute for Low Temperature Physics and Engineering, Kharkov, 61103, Ukraine — [4]University of Warwick, Department of Physics, Coventry CV4 7AL UK

We have investigated elastic properties of the spin-ice materials Dy2Ti2O7 (DTO) and Ho2Ti2O7 (HTO) for a wide range of temperature and magnetic field. Our studies of the sound characteristics for several acoustic modes evidence a renormalization of the sound velocity and the sound attenuation due to phase transformations at applied magnetic field as well as an interaction with low-energy magnetic excitations (topological defects). The most prominent anomalies are quasi-periodic peaks in the sound velocity and in the sound attenuation observed in DTO due to non-equilibrium processes arising in the external magnetic field. These results were analyzed theoretically using exchange-striction coupling, which shows a good agreement between theory and experiment. The obtained results at high magnetic fields exhibit some pronounced anomalies around 50 T for both compounds. Our calculations including crystal-electric field effects show satisfactory agreement with experiment.

MA 29: Micro- and Nanostructured Magnetic Materials

Time: Wednesday 15:00–18:00 Location: H23

MA 29.1 Wed 15:00 H23

On the correlation between material morphology, cation distribution and magnetic properties in nanocrystalline $ZnFe_2O_4$ — •Christian Reitz, Christian Suchomski, and Torsten Brezesinski — Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen

Magnetic materials exhibiting both a high saturation magnetization and low coercivity are of interest to researchers from a wide range of disciplines, including information technology, biomedicine and so forth. Inverse spinel ferrites, in which the Fe^{3+} ions are distributed equally among the octahedral and tetrahedral binding sites, constitute a promising class of materials for such applications. Bulk zinc ferrite (ZFO), by contrast, is known to adopt a normal spinel structure, which leads to antiferromagnetic behavior. Nonetheless, in recent years it has been shown that the cation distribution and, thus, also the magnetic properties of ZFO and related spinel ferrites can be effectively tai-

lored by changing the material morphology and by reducing the grain size to the nanometer level. Here we report facile synthetic routes for the preparation of sub 10 nm diameter nanoparticles and ordered mesoporous thin films of partially inverted ZFO. These oxide materials exhibit magnetic characteristics that strongly depend on the morphology, grain size and the cation distribution. The latter was determined by both XPS and Mössbauer spectroscopy.

MA 29.2 Wed 15:15 H23

Preparation and investigation of individual MnAs nanoclusters and nanocluster arrangements — •Martin Fischer[1], Matthias T. Elm[1], Shinjiro Hara[2], Christian Heiliger[1], and Peter J. Klar[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, D-35392 Gießen — [2]Research Center for Integrated Quantum Electronics, Hokkaido University, North 13 West 8, Sapporo, Japan 060-8628

Selective-area MOVPE-grown ferromagnetic MnAs nanoclusters are very interesting building blocks for completely new miniaturized magnetoelectronic devices in planar geometry. Due to the cluster growth on pre-patterned substrates, it is possible to tune their size, shape and position with high accuracy. This yields a high degree of freedom in the growth of various MnAs nanocluster devices for new planar magnetoelectronic applications. We report on the preparation of contacted, single MnAs nanoclusters and nanocluster arrangements consisting of clusters of different size and shape as well as the investigation of their structural and magnetotransport properties.

MA 29.3 Wed 15:30 H23

Magneto-plasmonic properties of Ni anti-dot nano-arrays in the presence of an external magnetic-field — •Evangelos Papaioannou[1,2], Burkard Hillebrands[1], Vassilios Kapaklis[2], Emil Melander[2], Erik Östman[2], and Björgvin Hjörvarsson[2] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — [2]Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden

Magneto-plasmonics offer unique possibilities to manipulate light by the use of external magnetic fields. The magnetic field can provide the means to control surface plasmons polaritons (SPPs), as it has been predicted for noble metals, and explored experimentally in hybrid structures composed of noble and magnetic metals/dielectrics. However no study has been devoted to pure magnetic metals. Here, we present the case of a pure magnetic metal, such as Ni patterned in a two-dimensional hexagonal lattice. The patterned Ni thin film supports the excitation of SPPs both at the air/Ni interface and Ni/substrate interface. The dispersion relation of SPPs defined by the hexagonal pattern can be modified with an application of a transverse magnetic field. This is revealed by the modulated reflectivity measured by the Transverse Magneto-optic Kerr Effect (TMOKE). The perspective of developing new ways to use combined magnetic field, magneto-optic and surface plasmon effects for manipulation of light is addressed.

MA 29.4 Wed 15:45 H23

Nanopatterning of linear GMR spin valves by FIB milling — •Benjamin Riedmüller, Felix Huber, and Ulrich Herr — Universität Ulm, Institut für Mikro- und Nanomaterialien

In this work we present a detailed investigation of a focused-ion-beam (FIB) nanopatterning process for linear spin valves consisting of Si/SiO_2[300]/Ta[5]/NiFe[6]/Co[1]/Cu[4]/Co[4]/FeMn[20]/Ta[5] (numbers are thickness in nm) to widths down to 150 nm. Our results show that without any further protective layer the spin valves show a drastic decrease in magneto-resistive (MR) properties after the FIB cutting even for widths >1 μm. This is accompanied by a decrease of interlayer exchange coupling (J_{ex}) at the AFM/FM interface. These results can be explained by a Ga bombardment near the cutting edges with stray irradiation of the ion beam which limits the process and does not allow a successive nanopatterning of the MR devices. The observed decrease in MR functionality can be correlated with a lateral ion irradiation that shows a similar decrease of the GMR-ratio and an increase in spin valve resistance for doses higher than $1 \cdot 10^{13}/cm^2$. For protecting the spin valves from the unwanted ion damage a 50 nm SiO_2 cover layer is deposited by ion beam evaporation on the spin valves. After FIB cutting a smaller decrease of the MR ratio and AFM/FM coupling can be seen which proves the protective function of the SiO_2 layer and therefore allows sensor dimensions < 200 nm. The nanostructuring is accompanied by a drastic change in the magnetic reversal and switching behaviour of the magnetic layers which can be understood as a consequence of the small widths of the sensor elements.

MA 29.5 Wed 16:00 H23

Magnetic domain walls in patterned exchange bias domains — •Alexander Gaul[1], Alla Albrecht[1], Hans Peter Oepen[2], Sebastian Hankemeier[2], and Arno Ehresmann[1] — [1]Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [2]Institute of Applied Physics and Microstructure Advanced Research Center, University of Hamburg, Jungiusstr. 11, D-20355 Hamburg

Arbitrary micro magnetic domain structures are fabricated by ion bombardment induced magnetic patterning (IBMP) [1] of exchange bias layer systems, where the size of magnetic domains together with the value and direction of the anisotropy parameter in adjacent domains can be deliberately set. These domain walls were probed by magnetic force microscopy (MFM) and scanning electron microscopy with polarization analysis (SEMPA) to reveal the detailed magnetic structure of the domain walls. Different structures like cross tie, zig zag and asymmetric domain walls were found depending on the properties of the nearby domains.

[1] Ehresmann, A., Engel, D., Weis, T., Schindler, A., Junk, D., Schmalhorst, J., Höink, V., et al. (2006). Fundamentals for magnetic patterning by ion bombardment of exchange bias layer systems. Phys. Stat. Sol. (B), 243(1), 29-36. doi:10.1002/pssb.200562442

MA 29.6 Wed 16:15 H23

Propagation of magnonic spin-wave modes in CoFeB waveguide — •Maria Mansurova, Benjamin Lenk, Stephan Shishkin, and Markus Münzenberg — I. Physikalisches Institut, Universität Göttingen, Germany

The understanding of guiding mechanisms of spin waves is highly important for the development of spin-wave logic gates. In this work, femtosecond laser pulses are used to optically excite (pump) and subsequently measure (probe) magnetization dynamics and spin wave propagation on a magnonic waveguide, which consists of a 16 μm wide defect line in a rectangular CoFeB antidot lattice, oriented either perpendicularly or at 45° to the bias magnetic field.

For each orientation of the magnetic field, spin wave spectra of the waveguide show the same modes as rectangular CoFeB antidot lattice, namely, Damon Eschbach (DE) surface mode, perpendicular spin standing wave (PSSW) and Kittel uniform precession (90° orientation only). These modes propagate both into the waveguide and continuous film, although DE mode is not normally present in the continuous CoFeB thin film spectra. Moreover, at 45° to the bias magnetic field orientation, the DE mode propagation length into the waveguide is larger compared to 90° orientation case.

15 min. break

MA 29.7 Wed 16:45 H23

Simultaneous measurement of AMR and observation of magnetic domains — Julia Osten[1,2], •Manuel Langer[1,2], Kilian Lenz[1], Jürgen Lindner[1], and Jürgen Fassbender[1,2] — [1]HZDR Institute of Ion-Beam Physics and Materials Research P.O. Box 510119, 01314 Dresden, Germany — [2]TU Dresden Helmholtzstr. 10, 01069 Dresden, Germany

Anisotropic magneto resistance (AMR) sensors are widely used in daily life. Nevertheless, the influence of magnetic domains on the AMR is still not fully understood. AMR depends on the angle between applied current and the direction of the internal magnetization, which is equal to the sum of all magnetic domains. For the understanding of the AMR it is important to know the domain structure.
In this experiment Kerr microscopy is used for the observation of the magnetic domains while at the same time the AMR is measured. The investigated permalloy films are stripe patterned by Cr^+ implantation. Amongst other effects the implantation leads to a lower saturation magnetization in the implanted stripes compared to the non-implanted ones.
Our measurements show a clear correlation between AMR and the magnetic domain structure. It is also possible to correlate stripe parameters to different domain types.

This work is supported by DFG grant FA316/3-2.

MA 29.8 Wed 17:00 H23

Studying the magnetization reversal of a permalloy antidot array by magnetic force microscopy — •Steffen Nothelfer, Felix Haering, Ulf Wiedwald, Berndt Koslowski, and Paul Ziemann — Ulm University, Institute of Solid State Physics, D-89069 Ulm, Germany

We study the magnetization of hexagonally arranged antidot arrays in permalloy thin films by analyzing the stray field of such films by means of magnetic force microscopy (MFM) in a variable magnetic field. Our investigations focus on such systems for which the magnetization behavior is governed by a spin ice rule, typically observed for lattice constants below 500nm and antidot diameters above 330nm. In this case, a simple magnetization model provides the possibility of reconstructing the magnetization pattern of the film from MFM images depending on the external magnetic field. A good correspondence of measurements employing MFM and X-ray magnetic circular dichroism [1,2] is found. Additionally, the controlled magnetization reversal of the film enables an isolation of the magnetic interaction from other interactions, e.g., the van der Waals interaction. We find a surprising exponential decay of the field perpendicular to the surface in the range of 0.03-0.3 lattice constants of the antidot lattice. This result agrees well with micromagnetic simulations.

[1] E. Mengotti, L. Heyderman, A. Fraile Rodríguez, F. Nolting, R. V. Hügli, and Hans-Benjamin Braun, Nature Physics 7, (2011).

[2] F. Hearing, U. Wiedwald, T. Häberle, L. Han, A. Plettl, B. Koslowski, P. Ziemann, submitted to Nanotechnology.

MA 29.9 Wed 17:15 H23

Magnetic stray field landscape design due to tailored magnetic domain wall charges between in-plane magnetic domain configurations — •Dennis Holzinger, Norbert Zingsem, Iris Koch, Alexander Gaul, Christoph Schmidt, 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

Ion bombardment induced magnetic pattering (IBMP)[1] of exchange bias layer systems is for the first time used as an outstanding tool for the deliberate design of arbitrary magnetic stray field landscapes. Thermally stable in-plane micro magnetic domain configurations with long-range translational symmetry are fabricated, differing in their individual domain properties concerning the magnitude and direction of anisotropy parameters, domain size, charge accumulation and domain wall angle within the same material system. Since the angle between the in-plane magnetized domains in adjacent domains can be precisely tailored by IBMP, the amount of magnetic net charges within the domain walls and hence, the strength and spatial distribution of the correlated magnetic stray field can be purposefully designed.

[1] Ehresmann, A., Engel, D., Weis, T., Schindler, A., Junk, D., Schmalhorst, J., Höink, V., Sacher, M. D. and Reiss, G. (2006), Fundamentals for magnetic patterning by ion bombardment of exchange bias layer systems. Phys. Status Solidi B, 243: 29-36. doi: 10.1002/pssb.200562442

MA 29.10 Wed 17:30 H23

How to make $La_{0.7}Sr_{0.3}MnO_3$ nanostructures without losing the magnetization — •Martin Wahler[1], Bastian Büttner[1], Hans-Helmuth Blaschek[1], Nico Homonnay[1], Olga Wid[1], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Heinrich-Damerow-Str. 4, 06120 Halle, Germany

The ferromagnetic oxide $La_{0.7}Sr_{0.3}MnO_3$ has a high spin polarization and T_C>300 K. It is thus a good candidate for all-oxide microelectronic devices exploiting effects like the spin transfer torque and spin pumping. For state-of-the-art microelectronics applications, however, lateral dimensions are in the sub-100 nm regime and suitable patterning processes need to be developed. For ferromagnetic oxides this can be complicated. Many dry etching processes like Ar ion milling can achieve a reasonable pattern geometry, however, at the cost of a loss of magnetization in the nanostructures because of process induced defects. We have developed a process in which a resist mask is defined by e-beam lithography. Using a chlorine-based RIE step an array of about 70 million rectangles with dimensions of each approximately 100 nm times 230 nm is fabricated from a 20 nm thick LSMO layer. The magnetic properties are measured using a SQUID vibrating sample magnetometer and show no loss of magnetization compared to the unpatterned layer. Ferromagnetic resonance measurements indicate that the patterning also overcomes the built-in crystalline anisotropy of the LSMO layer. We acknowledge the support by the EU-project IFOX.

MA 29.11 Wed 17:45 H23

Fabrication of high-density magnetic storage elements bylow-dose ion beam irradiation — •Roland Neb[1], Thomas Sebastian[1], Philipp Pirro[1], Stefan Pofahl[2], Rudolf Schaefer[2], Bernhard Reuscher[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Research Center Optimas, TUKaiserslautern, 67663 Kaiserslautern, Germany — [2]Leibniz-Institutfür Festkörper- und Werkstoffforschung Dresden, IFW Dresden, 01069 Dresden,Germany — [3]Institut für Oberflächen- und Schichtanalytik,IFOS, 67663 Kaiserslautern, Germany

A new scheme of fabricating magnetic storage elements is proposed. We irradiate an antiferromagnetically coupled Fe/Cr/Fe trilayer with a focused low-dose 30 keV Ga^+-ion beam. The irradiation leads to ferromagnetic coupling in the affected areas, rendering them capable of storing information. The working principle is demonstrated for a storage array with a bit density of 7 Gbit/inch^2. We also investigate the possibilities of increasing the bit density by numerical simulation and theoretical calculation, showing that from a physical point of view bit densities of over 1 Tbit/inch^2 are feasible.

MA 30: Focused Session: Majorana Fermions in Condensed Matter (jointly with DS, HL, MA, and O)

Majorana fermions arise as quasi-particle excitations in condensed matter systems which exhibit non-Abelian exchange statistics. This property makes them a fundamentally new type of particles, and possibly allows topological quantum computing in this system. In the last few years, the study of Majorana fermions has rapidly evolved from being a mere theoretical concept to a practical realization: Following theoretical proposals involving hybrid nanosystems consisting of conventional superconductors and semiconducting nanowires, experiments have now found signatures of Majorana fermions. This Focused Session will discuss various aspects of Majorana fermions and the hybrid systems hosting them, including both theoretical and experimental contributions.

Organizers: Fabian Hassler (RWTH Aachen), Michael Wimmer (Leiden University)

Time: Wednesday 15:00–18:00 Location: H20

Invited Talk MA 30.1 Wed 15:00 H20

Subgap States in Majorana Wires — •Piet Brouwer — Freie Universität Berlin

A one-dimensional spin-orbit coupled nanowire with proximity-induced pairing from a nearby s-wave superconductor may be in a topological nontrivial state, in which it has a zero energy Majorana bound state at each end. In this talk, I will discuss how non-idealities in this proposal, such as potential disorder, deviations from a strict one-dimensional limit, or details concerning the termination of the wire, affect the topological phase and its signatures in a current-voltage measurement. In particular, I'll argue that the topological phase can persist at weak

disorder or for multichannel wires, although some of the signatures of the presence of Majorana fermions are obscured.

Invited Talk MA 30.2 Wed 15:30 H20
New Measurements on Nanowire Majorana Systems — •Charles Marcus[1,3], Hugh Churchill[2,3], Mintang Deng[4], and Hongqi Xu[4] — [1]Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, Copenhagen, DK — [2]Department of Physics, MIT, Cambridge, MA USA — [3]Department of Physics, Harvard University, Cambridge, MA USA — [4]Division of Solid State Physics, Lund University, Lund, Sweden

This talk will present recent measurements on gated InSb nanowires coupled to a superconducting film. This set-up is one designed to detect Majorana end states. We show data similar to that seen in other groups recently, and also extend measurements in a number of directions, including higher field and higher conductance. Oscillatory structure suggesting interacting end-state Majoranas is found. We also identify transport regimes where even-odd Kondo-like features are evident, combined with Andreev bound states.

This research is sponsored by Microsoft Project Q, the Danish National Research Foundation, and Harvard University.

Topical Talk MA 30.3 Wed 16:00 H20
Adaptive Tuning of Majorana Fermions in a Quantum Dot Chain — •Anton Akhmerov — Harvard University, USA

I will explain how to overcome the obstacles that disorder and high density of states pose to the creation of unpaired Majorana fermions in one-dimensional systems. This is achieved by splitting the system into a chain of quantum dots, which are then tuned such that the chain can be viewed as an effective Kitaev chain with maximally localized Majorana fermions. Resonant Andreev spectroscopy allows us to make this tuning adaptive, so that each pair of dots may be tuned independently of the other. Our numerical simulations show that already in three quantum dots it is possible to have almost completely decoupled Majorana fermions.

15 min. break

Topical Talk MA 30.4 Wed 16:45 H20
Majorana Fermions in Disordered Quantum Wires — •Alexander Altland — Institute for Theoretical Physics, Zülpicher Str. 77, 50937 Köln

Proximity coupled spin-orbit quantum wires have recently been shown to support midgap Majorana states at critical points. We show that in the presence of disorder these systems are prone to the buildup of a second bandcenter anomaly, which is of different physical origin but shares key characteristics with the Majorana state: it is narrow in width, insensitive to magnetic fields, carries unit spectral weight, and is rigidly tied to the band center. Depending on the parity of the number of subgap quasiparticle states, a Majorana mode does or does not coexist with the impurity generated peak. The strong 'entanglement' between the two phenomena may hinder an unambiguous detection of the Majorana by spectroscopic techniques.

Topical Talk MA 30.5 Wed 17:15 H20
Parity Effects and Crossed Andreev Noise in Transport through Majorana Wires — •Bernd Rosenow[1], Björn Zocher[1,2], and Mats Horsdal[1] — [1]Institut für Theoretische Physik, Universität Leipzig, D-04009 Leipzig, Germany — [2]Max-Planck-Institute for Mathematics in the Sciences, D-04103 Leipzig, Germany

One of the defining properties of a topologically ordered state is the ground state degeneracy on surfaces with nonzero genus. In semiconductor-superconductor hybrid structures, a phase transition between regular and topologically nontrivial superconductivity is expected as a function of chemical potential or magnetic field strength. The difference in ground state degeneracies of the two phases is reflected in the parity and magnetic flux dependence of nonlinear Coulomb blockade transport through a ring shaped structure.

In nanowires of finite length, topologically non-trivial superconductivity is expected to give rise to Majorana bound states at the ends of the wire. The non-locality of Majorana bound states opens the possibility of crossed Andreev reflection with nonlocal shot noise, due to the injection of an electron into one end of the superconductor followed by the emission of a hole at the other end. When coupling the end states to leads via quantum dots with resonant levels, in the space of energies of the two resonant quantum dot levels we find a four peaked clover-like pattern for the strength of noise due to crossed Andreev reflection, distinct from the single ellipsoidal peak found in the absence of Majorana bound states.

MA 30.6 Wed 17:45 H20
Majorana qubit rotations in microwave cavities — •Thomas L. Schmidt, Andreas Nunnenkamp, and Christoph Bruder — Department of Physics, University of Basel, CH-4056 Basel, Switzerland

Majorana bound states have been proposed as building blocks for qubits on which certain operations can be performed in a topologically protected way using braiding. However, the set of these protected operations is not sufficient to realize universal quantum computing. We show that the electric field in a microwave cavity can induce Rabi oscillations between adjacent Majorana bound states. These oscillations can be used to implement an additional single-qubit gate. Supplemented with one braiding operation, this gate allows to perform arbitrary single-qubit operations.

MA 31: Focus Session: Magnetic Damping Phenomena in Thin Films and Nanostructures (jointly with DS)

Organizers: J. Lindner (HZDR), H. Ebert (TU München)
New emerging technologies for enhanced magnetic information storage require an improved understanding and control of the mechanisms that influence the magnetization reversal and stability on the nanoscale. The key property in this context is magnetic relaxation as it governs all processes that invoke the dynamic behavior of the magnetization. In this session we aim to discuss recent progress in understanding intrinsic Gilbert damping as well as extrinsic relaxation channels which are relevant for the timescales of femto- to nanoseconds. Besides experimental approaches in time and frequency domain, state-of-the art theoretical descriptions on an ab-initio basis as well as model calculations are reviewed.

Time: Wednesday 15:00–17:30 Location: H10

Topical Talk MA 31.1 Wed 15:00 H10
An overview of magnetic damping in ferromagnets — •Robert McMichael — National Institute of Standards and Technology, Center for Nanoscale Science and Technology, Gaithersburg MD USA

Many of the applications for magnetic nanotechnology depend on the ability to write and read information quickly by switching and measuring the magnetization in magnetic nanostructures, and the magnetic damping plays an important role in the dynamics. The desired amount of damping depends on the application. For example, in some cases, strong damping enables fast switching, while in other cases strong damping prevents switching. In this talk, I will give a brief introduction to the phenomenology of damping, or relaxation, of magnetization in ferromagnets, which is often nicely described by a viscous drag or Gilbert damping. I aim to supplement this phenomenological picture by reviewing the current understanding of damping mechanisms in ferromagnetic metals. The primary mechanism involves transferring energy to electronic states near the Fermi surface. Additionally, in

nanostructures, the dynamic effects of damping can be modified by spin polarized currents either that are injected from external sources or that are generated spontaneously by the magnetization precession. I will conclude by focusing on problems of interpreting damping measurements in materials with defects, and on the opportunities for intrinsic damping measurements in nanostructures.

Topical Talk MA 31.2 Wed 15:30 H10

Magnetic Damping on Femtosecond Time Scales — •Markus Münzenberg — Georg-August University, I. Phys. Institute, Göttingen, Germany

Achieving high speed magnetization dynamics in magnetic materials is at the heart of the engineering of spin-based electronic devices. Microscopic processes in a magnetic materials involve electrons, their spins, and their interactions with phonons. Materials with low damping constants can be realized by controlling the spin-flip channels at the Fermi level. Metallic Heusler compounds show a Gilbert damping of 0.002-0.006, however, the theoretically predicted values are $10^{-5} - 10^{-4}$.

The experiments we report in this talk demonstrate a successful control of spin polarization and spin dynamics on ultrafast time scales in magnetic materials through their electronic structure. For achieving a systematic variation in their electronic structure as a control, we have made a selection of so-called half-metals, in the family of the Heusler compounds and pseudogap materials that are close relatives, but their electronic structure is robust against structural disorder. Interestingly, similar values of spin polarization are seen in the pseudogap materials as well, making them another promising class of high-spin-polarization materials.

[1] A. Mann, J. Walowski, M. Münzenberg, S. Maat, M. J. Carey, J. R. Childress, C. Mewes, D. Ebke, V. Drewello, G. Reiss, A. Thomas, Phys. Rev. X 2, 041008 (2012).

Topical Talk MA 31.3 Wed 16:00 H10

Two-Magnon Excitations: From Periodical Perturbations to Magnonic Crystals — •Kilian Lenz — Magnetism Division, Institute for Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01324 Dresden

Two-magnon scattering is a well-known effect e.g. in ferromagnetic resonance experiments leading to a linewidth broadening. Available theory so far was based on random defects acting as a dipolar scattering potential. Recently it was shown by Landeros and Mills [1] that this theory can be extended to handle two-magnon scattering in *periodically* perturbed films, which can be easily created by lithographical patterning. These perturbed films are the intermediate step towards full magnonic crystals. The extended model allows for analytically calculating the response function of 1D and 2D periodically perturbed ferromagnetic films in almost perfect agreement to FMR experiments as I will show. A striking feature e.g. is the mode splitting due to the two-magnon scattering which opens magnonic band gaps. This splitting can be tailored by the geometric and magnetic sample parameters.

This work was supported by the DFG grants FA 314/6-1, FA314/3-2.

[1] P. Landeros and D. L. Mills, Phys. Rev. B 85, 054424 (2012).

Topical Talk MA 31.4 Wed 16:30 H10

Gilbert damping parameter from first-principles — •Diemo Ködderitzsch[1], Sergiy Mankovsky[1], Hubert Ebert[1], and Georg Woltersdorf[2] — [1]Universität München, Dept. Chemie, Butenandtstraße 5-13, D-81377 München, Germany — [2]Universität Regensburg, Fak. f. Physik, Universitätsstraße 31, 93040 Regensburg, Germany

Conventionally, magnetisation dynamics is discussed on the basis of the Landau-Lifshitz-Gilbert equation containing a damping term for the magnetisation. So far in first-principles calculations, the scattering processes responsible for the transfer of energy associated with the magnetisation to the lattice (due to spin-orbit coupling) are usually represented by an adjustable relaxation time parameter. Recent approaches tackled this problem by introducing a scheme employing scattering theory. [1,2] We here present a general approach to calculate the damping parameter from first-principles based on the linear response Kubo formalism, as implemented within the fully relativistic Korringa-Kohn-Rostoker band structure method. This approach allows, in particular, to account for scattering processes due to chemical disorder or thermal lattice vibrations. Results for 3*d* transition-metals and their alloys, and impurity systems, compared to experiment demonstrate the viability of the approach. [3,4]

[1] Brataas *et al.*, PRL **101**, 037207 (2008) [2] Starikov *et al.*, PRL **105**, 236601 (2010) [3] Ebert, Mankowsky, Ködderitzsch and Kelly, PRL **107**, 066603 (2011) [4] Mankowsky, Ködderitzsch, Woltersdorf and Ebert, submitted to PRB (2012)

Topical Talk MA 31.5 Wed 17:00 H10

Spin dynamics and relaxation in ferrimagnets — Frank Schlickeiser, Sönke Wienholdt, Denise Hinzke, and •Ulrich Nowak — Universität Konstanz, 78457 Konstanz, Germany

Recent experiments on all-optical switching in GdFeCo [1] have focused much attention on the spin dynamics of ferrimagnets. The understanding of relaxation mechanisms is here even more complicated than in a ferromagnet due to the fact that the two sublattices of the ferrimagnet can exchange energy and angular momentum without dissipation, keeping the total energy and angular momentum constant.

We discuss the theory of the dynamics of ferrimagnets on different length scales, ranging from microscopic spin models to mesoscopic descriptions with a two-sublattice Landau-Lifshitz-Bloch equation. Our results for the temperature dependence of the frequencies and effective damping parameters of the normal modes represent a generalization and improvement of formetwo-sublatticer approximated solutions [2]. Furthermore, we discuss the role of angular momentum conservation and dissipation for the recently discovered transient ferromagnetic-like state [3] and for the pure thermal switching of ferrimagnets [4].

This work received funding from the EC (Collaborative Project FEMTOSPIN) and from the CAP at the University of Konstanz.

[1] K. Vahaplar *et al.*, Phys. Rev. Lett. **103**, 117201 (2009).
[2] F. Schlickeiser *et al.*, Phys. Rev. B, in press.
[3] I. Radu *et al.*, Nature **472**, 205 (2011).
[4] T. A. Ostler *et al.*, Nat. Commun. **3**, 666 (2012).

MA 32: Focus Session: Spin Current Devices

Organizers: S.O. Demokritov (Westfälische Wilhelms-Universität Münster), S.T.B. Goennenwein (Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching), B. Hillebrands (Technische Universität Kaiserslautern)

Spin currents are the spin angular momentum analogue of conventional charge currents. They thus represent a fundamental building block for spintronic devices in the proper sense of the word, in which only spin information is transported, manipulated and stored, while no charge motion is required. In this session, different spin current device concepts will be described, in conjunction with an overview over fundamental spin current physics.

Time: Thursday 9:30–12:00 Location: H10

Topical Talk MA 32.1 Thu 9:30 H10

Spin Hall and spin Nernst effect from first principles — •Ingrid Mertig — Martin Luther University Halle-Wittenberg, 06099 Halle, Germany

Spintronics without magnetic materials is an interesting alternative to the existing spintronics applications. The spin Hall effect creates spin currents in nonmagnetic materials and avoids the problem of spin injection. Future applications of the spin Hall effect require two properties of the materials, a large spin Hall angle and a long spin diffusion length. Ab intio calculations based on density functional theory are a powerful tool to design the desired materials and to get insight into the underlying microscopic processes. We investigated the spin Hall

effect in dilute alloys, in particular the intrinsic effect based on the Berry curvature as well as the side-jump and skew-scattering contributions. The results demonstrate that a large extrinsic spin Hall effect is determined by the differences between host and impurity concerning the spin-orbit interaction. An alternative way is to deposit impurities in the adatom position of thin films. Furthermore, we predict a spin current perpendicular to a temperature gradient. The phenomenon is called spin Nernst effect.

Topical Talk MA 32.2 Thu 10:00 H10

Spin currents in ferromagnetic insulator/normal metal hybrids — •Matthias Althammer — Walther-Meißner-Institut, BAdW, Germany — University of Alabama, MINT Center, Tuscaloosa, USA

The controlled generation, manipulation, and detection of spin currents (i.e., of flows of spin angular momentum without an accompanying net flow of charge) - is the key to novel spin transport schemes and novel spintronic devices. We have experimentally investigated pure spin currents in ferromagnetic insulator/normal metal hybrid structures, using yttrium iron garnet, nickel ferrite, or magnetite for the magnetic insulator, and Pt, as well as Cu or Au, for the normal metal layer. On the one hand, we use spin pumping measurements to quantify the spin mixing conductance in our hybrid structures. On the other hand, we observe a novel magnetoresistive effect upon driving a conventional charge current through the Pt. This so-called spin Hall magnetoresistance (SMR) arises from the combined action of spin Hall and inverse spin Hall effect in Pt [1]. The SMR characteristically depends on the magnetization orientation in the magnetic insulator, although no electrical current flows through the latter. The SMR is qualitatively different from the anisotropic magnetoresistance effect arising in ferromagnetic metals, and in particular persists also when a thin Cu or Au layer is inserted between the magnetic insulator and the Pt layer. Taken together, the SMR thus represents a simple and powerful tool for the study of spin current transport in magnetic hybrid structures.

[1] H. Nakayama et al., arXiv 1211.0098.

Topical Talk MA 32.3 Thu 10:30 H10

From magnon flow to spin current and back — •Andrii Chumak — Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Magnons have great potential for applications in the transfer and processing of spin information in spintronics. However, this potential can only be fulfilled if an effective means to convert magnon flows into electron-carried spin and charge currents and back is found. The first part of my talk will concentrate on magnon to charge current converters exploiting a combination of two separate physical phenomena: spin pumping, and the inverse spin Hall effect (SHE). In these systems, a precessing magnetization in a magnetic film results in the injection of a spin current into a normal metal layer on its surface through spin pumping and this spin current is then converted into a charge current via the inverse SHE. I shall present a set of experimental results on yttrium iron garnet (YIG) - Pt bi-layers demonstrating that magnons having wavelengths spanning a wide range (from centimeters down to a hundred nanometers) efficiently contribute to spin pumping. I shall also discuss a way of improving of the YIG-Pt interface capable of increasing the spin pumping efficiency. Next I shall discuss charge current to magnon conversion via the direct SHE and spin transfer torque (STT) in similar structures. Our experiments show that passing a DC current through a surface Pt layer results in a variation of spin-wave damping of up to twenty percent in a two-micron thick YIG film. We acknowledge financial support by the DFG (project CH 1037/1-1).

Topical Talk MA 32.4 Thu 11:00 H10

Interaction between spin waves and magnetic domain walls in insulating ferromagnets — •Peng Yan — Kavli Institute of NanoScience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands

The interplay between spin waves (SWs) and magnetic domain walls (DWs) leads to very rich physics. On one hand, the injection of SWs through a DW tends to drive the DW moving against the SW propagation direction. The mechanism is identified as a magnonic spin transfer torque which is the counterpart of its electronic version [1]. On the other hand, the DW under a static magnetic field can propagate along a dissipationless nanowire through SW emission (or pumping), since SWs carry away both energy and angular momentum [2]. The opposite effect, viz. the modulation of the magnon-mediated heat current by a domain wall is also investigated [3]. In the regime of validity of continuum micromagnetism, a DW is found to have no effect on the heat conductance. However, SWs are found to be reflected by DWs with widths of a few lattice spacings, which is associated with emergence of an additional spin wave bound state. The resulting DW heat conductance should be significant for thin films of yttrium iron garnet with sharply defined magnetic domains.

[1] P. Yan *et al.*, PRL **107**, 177207 (2011).
[2] X.S. Wang, P. Yan *et al.*, PRL **109**, 167209 (2012).
[3] P. Yan and G.E.W. Bauer, PRL **109**, 087202 (2012).

Topical Talk MA 32.5 Thu 11:30 H10

Current driven domain wall dynamics controlled by proximity induced interface magnetization — •Stuart Parkin — IBM Almaden Research Center, San Jose, California, USA

Ultra-thin perpendicularly magnetized nanowires are the ideal medium for high-density memory and logic devices based on magnetic domain walls. Recently it has been reported that domain walls can be driven by current at very high speed in such nanowires. The high velocity and the direction of motion of the domain walls are inconsistent with conventional theories based on transfer of spin angular momentum from the current. Here we show in nanowires formed from atomically thin Co and Ni layers that interfaces with specific metal layers control both the speed and direction of the domain walls. These layers are formed from non-magnetic metals, namely Pt, Pd and Ir, which become magnetic in proximity to strong ferromagnets. When the induced moment is suppressed by the insertion of atomically thin Au layers the domain walls are considerably slowed. We show that the mechanism driving the domain walls derives from the intertwined phenomena of spin Hall currents in the non-magnetic layers and a Dzialoshinskii-Moriya interaction at the cobalt- non-magnetic interface that fixes the chirality of the domain walls.

MA 33: Magnetization Dynamics I of 3

Time: Thursday 9:30–12:00 Location: H22

MA 33.1 Thu 9:30 H22

Ultrafast transiently inversed magnetization in TbCo alloys — •Sabine Alebrand[1], Ute Bierbrauer[1], Michel Hehn[2], Matthias Gottwald[2,3], Oliver Schmitt[1], Daniel Steil[1], Eric E. Fullerton[3], Stéphane Mangin[2], Mirko Cinchetti[1], and Martin Aeschlimann[1] — [1]Dep. of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]IJL, Université de Lorraine, Nancy, France — [3]University of California, San Diego, USA

Since the discovery of all-optical magnetization switching in 2007 [1], the rare earth (RE) -transition metal (TM) alloy GdFeCo gained special attention. In 2011 Radu et al. [2] performed an XMCD experiment on GdFeCo, which allows to detect the magnetization dynamics of both the Gd- and FeCo-sublattice seperately. They found that the two sublattices not only demagnetize after laser exciation but they can even transiently be switched on a subpicosecond timescale.

We focus on the RE-TM alloy TbCo which combines all-optical switching with high perpendicular anisotropy [3]. We performed time-resolved magneto-optical Kerr measurements, investigating the fluence and composition dependent ultrafast demagnetization behavior. We find that for equal excitation conditions the demagnetization strength of the Co sublattice strongly depends on the Tb concentration. Moreover for $Tb_{32}Co_{68}$ we observe a transient magnetization switching of the Co sublattice on a timescale similar the one in GdFeCo. The magnetization switched state can last for several picoseconds.

[1] Stanciu et al. PRL 99, 047601 (2007) [2] Radu et al. Nature 472, 205-208 (2011) [3] Alebrand et al. APL 101, 162408 (2012)

MA 33.2 Thu 9:45 H22

Thermally assisted all-optical helicity dependent magnetic

switching in $Fe_{100-x}Tb_x$ films — Alexander Hassdenteufel[1], Birgit Hebler[1], Christian Schubert[1], •Andreas Liebig[1], Martin Teich[2,3], Manfred Helm[2,3], Martin Aeschlimann[4], Manfred Albrecht[1], and Rudolf Bratschitsch[1] — [1]Institute of Physics, Chemnitz University of Technology, D-09107 Chemnitz (Germany) — [2]Helmholtz Zentrum Dresden Rossendorf, P. O. Box 510119, D-01314 Dresden (Germany) — [3]Technische Universität Dresden, D-01062 Dresden (Germany) — [4]Department of Physics and Research Center Optimas, University of Kaiserslautern, D-67663 Kaiserslautern (Germany)

Magnetization switching is at the heart of both modern information storage technology and fundamental science. Ultrafast laser pulses are promising to explore and finally reach the ultimate speed limit of this process. We present all-optical switching (AOS) in amorphous ferrimagnetic $Fe_{100-x}Tb_x$ alloy films with circularly polarized laser pulses. A Tb content of 22 to 34 at.% is necessary for AOS to occur. Outside this composition range pure thermal demagnetization is observed. AOS occurs not only below and above the magnetic compensation temperataure (T_{comp}), but also in samples without T_{comp}. We find that AOS is associated with laser heating up to the Curie temperature. AOS is intimately linked to a low remanent sample magnetization M_R. Above a threshold magnetization of 220 emu/cc helicity dependent AOS is replaced by pure thermal demagnetization.

MA 33.3 Thu 10:00 H22

Tuning the timescale of ultrafast demagnetization in GdTb alloys through spin-lattice coupling — •Andrea Eschenlohr[1,2], Muhammad Sultan[1], Nicolas Bergeard[1], Alexey Melnikov[3], Jens Wieczorek[1], Torsten Kachel[2], Christian Stamm[2], and Uwe Bovensiepen[1] — [1]Fakultät für Physik and Center for Nanointegration (CeNIDE), Universität Duisburg-Essen — [2]Institut für Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH — [3]Fritz-Haber-Institut der MPG, Berlin

Pure Gd and Tb show femtosecond laser-induced demagnetization in two steps, with the time constant of the second, slower step depending on the strength of coupling of the $4f$ magnetic moments to the lattice [Wietstruk et al., PRL **106**, 127401 (2011)]. In time-resolved magneto-optical Kerr effect measurements on GdTb alloys, we see a decrease of this time constant from 33 ps to 9 ps with Tb content increasing from 0 to 70 %, due to the strong spin-lattice coupling of Tb. In time- and element-resolved x-ray magnetic circular dichroism measurements at the BESSY II Femtoslicing source concomitant dynamics of the Gd and Tb magnetization components is observed, revealing an increased coupling of the Gd $4f$ magnetic moments to the lattice via indirect exchange coupling to the neighboring Tb $4f$ moments, so that demagnetization of Gd in the alloy is accelerated compared to the pure material.

We acknowledge funding from BMBF Grant 05K10PG2 Femtospex and the DAAD-HEC Pakistan.

MA 33.4 Thu 10:15 H22

Ultrafast magnetic dynamics in the metallic 4f antiferromagnet Holmium — •Christoph Trabant[1,2,3], Niko Pontius[2], Hartmut Zabel[4], Alexander Föhlisch[2,3], and Christian Schüssler-Langeheine[2] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Methoden und Instrumentierung der Synchrotronstrahlung, Helmholtz-Zentrum Berlin — [3]Institut für Physik und Astronomie, Universität Potsdam — [4]Institut für Experimentalphysik / Festkörperphysik, Ruhr Universität Bochum

We studied the laser induced fs magnetic dynamics of a metallic 4f antiferromagentic Holmium thin film. The dynamics was mapped using the strong resonant x-ray scattering signal of the helical magnetic (00τ) superstructure reflection. We found a fast quenching of the magnetic order on a $\sim$ 200 fs timescale which is essentially independent of the applied laser fluence. Comparing this demagnetization time and those of the the 4f ferromagnets Terbium and Gadolinium (750 fs each) [1] to their respective atomic magnetic moment (Gd: $7.55\mu_B$, Tb: $9.3\mu_B$, and Ho: $10.6\mu_B$) leads to the conclusion that the time constant does not scale with the size of the magnetic moment as proposed for ferromagnets. The optical pump xray probe measurements have been performed at the FEMTOSPEX facility at BESSY II. Supported by the BMBF through contract 05K10PK2.
[1] M. Wietstruk, et al.: PRL 106, 127401 (2011).

MA 33.5 Thu 10:30 H22

On the role of the transient ferromagnetic-like state and of the magnetization compensation temperature in all-optical magnetization switching in GdFe ferrimagnetic alloys — •Loïc Le Guyader[1,2], Ilie Radu[2], Souliman El Moussaoui[1], Michele Buzzi[1], Ilya Razdolski[3], Rajasekhar Medapalli[3], Matteo Savoini[3], Christian Stamm[2], Rolf Mitzner[2], Karsten Holldack[2], Torsten Kachel[2], Arata Tsukamoto[4], Akiyoshi Itoh[4], Frithjof Nolting[1], Andrei Kirilyuk[3], Theo Rasing[3], and Alexey Kimel[3] — [1]Swiss Light Source, Paul Scherrer Institut, Villigen, Switzerland — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — [3]Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands — [4]College of Science and Technology, Nihon University, Chiba, Japan

Understanding the ultrafast all optical magnetization reversal is a challenging issue which could have tremendous impact for the magnetic recording industry. Combining femtosecond X-ray transmission measurements with picosecond time-resolved photo-emission electron microscopy, both using X-ray magnetic circular dichroism, we report on new insights into the ultrafast magnetization switching in GdFe ferrimagnetic alloys. In particular, we demonstrate that a prerequisite for all optical magnetization switching is the existence of a transient ferromagnetic-like state. Indeed, for sample temperature far from the magnetization compensation temperature, such transient state is not observed, leading to no switching behaviour.

MA 33.6 Thu 10:45 H22

Ultrafast Magnetization Dynamics in Co-Based Heusler Compounds with Tuned Structural Order — •Daniel Steil[1], Takahide Kubota[2], Mikihiko Oogane[2], Yasuo Ando[2], Christian G.F. Blum[3], Sabine Wurmehl[3], Anna Suszka[4], Olatz Idigoras[4], Andreas Berger[4], Martin Aeschlimann[1], and Mirko Cinchetti[1] — [1]Dept. of Physics and Res. Center OPTIMAS, TU Kaiserslautern, Germany — [2]Tohoku University, Sendai, Japan — [3]IFW Dresden, Germany — [4]CIC nanoGUNE, San Sebastian, Spain

Several Heusler compounds are predicted to be half-metallic ferromagnets (FM), making them interesting sources of spin-polarized currents. Time-resolved Kerr magnetometry (TR-MOKE) was suggested as a probe for half-metallicity, as a minority band gap should slow down magnetization dynamics compared to the 3*d*-FM [1]. However, Heusler compounds typically show magnetization dynamics similar to the 3*d*-FM [1-3], which has been partly attributed to defect states destroying the half-metallicity [1]. We studied thin films of Co_2MnSi (CMS) and Co_2FeSi (CFS) with different defect concentrations, as well as bulk single crystals with TR-MOKE to elucidate the influence of defects on magnetization dynamics. Surprisingly, we find no influence of defects on ultrafast dynamics in both systems, but a second demagnetization step in CMS for high defect concentrations. Single crystals of CFS and CMS show similar dynamics as the thin films. We discuss our results considering the DOS of the systems using the model from Ref. [2].

[1] G.M. Müller et al.; NMat **8**, 56 **(2009)** [2] D. Steil et al., PRL **105**, 217202 **(2010)** [3] J.-P. Wüstenberg et al., PSS B **248**, 2330 **(2011)**

MA 33.7 Thu 11:00 H22

Ultrafast spin dynamics in epitaxial Co/Cu(001) analyzed by femtosecond time-resolved linear and non-linear magneto optics — •Jens Wieczorek, Nicolas Bergeard, Alexander Tarasevitch, and Uwe Bovensiepen — Universität Duisburg-Essen, Fakultät für Physik, 47057 Germany

In order to investigate the microscopic processes in laser-induced demagnetisation, we performed pump probe measurements at Co/Cu(001)films at thicknesses 5 ML$< d <$ 30 ML. We used simultaneously time resolved magneto-optical Kerr effect(MOKE)and magneto induced second harmonic generation (MSHG) in a transversal geometry. The transient nonlinear MSHG signal is essentially independent on thickness, whereas the linear MOKE signal shows an increasing pump induced demagnetisation ΔM and an increase in the demagnetization time for larger d. Since MSHG is generated at the films interfaces and MOKE probes the film as a whole we conclude from the observed thickness dependence that different mechanisms contribute to the laser- induced change of the magnetization. At smallest d transport contributions might represent the dominant channel[1,2], while for larger d also slower, local processes like angular momentum transfer to phonons[3] become relevant.

We acknowledge support by the DFG through SFB616. [1] M. Battiato et al., PRL **105**, 027203 (2010) [2] A. Melnikov et al., PRL **107**, 076601 (2011) [3] Koopmans et al., Nat Mat 9, **259** (2010)

MA 33.8 Thu 11:15 H22

Tuning the Ultrafast Spin Dynamics in Magnetic Alloys — •Ilie Radu[1], Christian Stamm[1], Andrea Eschenlohr[1], Kadir Vahaplar[2], Torsten Kachel[1], Niko Pontius[1], Rolf Mitzner[1], Karsten Holldack[1], Alexander Föhlisch[1], Florin Radu[1], Richard Evans[3], Thomas Ostler[3], Johan Mentink[2], Roy Chantrell[3], Arata Tsukamoto[4], Akiyoshi Itoh[4], Andrei Kirilyuk[2], Alexey Kimel[2], and Theo Rasing[2] — [1]Helmholtz-Zentrum Berlin, BESSY II, Germany — [2]Radboud University Nijmegen, The Netherlands — [3]University of York, United Kingdom — [4]Nihon University, Chiba, Japan

The microscopic mechanisms behind the ultrafast, laser-driven demagnetization remain an intriguing and actively debated issue of ultrafast magnetism. Here we report on laser-driven dynamics of multi-sublattice magnetic materials, with both ferromagnetic and antiferromagnetic coupling between sublattices, investigated using element-specific, femtosecond time-resolved XMCD. These measurements [1], fully supported by phenomenological modeling and atomistic spin simulations, provide evidence for a demagnetization time that scales with the elemental magnetic moment and varies with the sign of the exchange interaction. As such, one can tune the speed of magnetization processes in multi-sublattices alloys, being either switching or demagnetization, by properly choosing the magnitude of the constituent magnetic moments and the sign of the exchange interaction that couples them, as exemplified for the case of a synthetic ferrimagnet. [1] I. Radu et al., submitted (2012)

MA 33.9 Thu 11:30 H22

Ultrafast loss of the classical magnetization — •Andreas Fognini[1], Gerard Salvatella[1], Florian Sorgenfrei[2], Martina Dell'Angela[3], Martin Beye[2], Florian Hieke[3], Dima Kutnyakhov[4], Pavel Lushchyk[4], Andrea Eschenlohr[2], Sanne de Jong[5], Roopali Kukreja[5], Natalia Gerasimova[6], Harald Redlin[6], Joerg Raabe[7], Andreas Oelsner[8], Christian Stamm[2], Urs Ramsperger[1], Joachim Stöhr[5], Hermann Dürr[5], Alexander Föhlisch[2], Wilfried Wurth[3], Gerd Schönhense[4], Andreas Vaterlaus[1], Thomas Michlmayr[1], and Yves Acremann[1] — [1]ETH Zürich, Schweiz — [2]HZB Berlin, Deutschland — [3]Uni. Hamburg, Deutschland — [4]Uni. Mainz, Deutschland — [5]SLAC, Stanford, USA — [6]DESY, Hamburg, Deutschland — [7]PSI, Villigen, Schweiz — [8]Surface Concept GmbH, Mainz, Deutschland

If a ferromagnet is exposed to an ultrafast laser pulse its magnetization can be reduced within less than a picosecond. Most detection schemes for the magnetization focus on electrons close to the Fermi energy or the density of empty states. The *classical* magnetization (the average spin polarization of the whole valence band) is difficult to detect. Here we present a method based on spin and time resolved photoemission using free electron laser radiation. A femtosecond 800nm laser pulse excites an Iron film. Vacuum ultraviolet pulses from the free electron laser FLASH in Hamburg extract polarized photoelectrons. Their spin polarization is detected by a Mott polarimeter as well as a novel spin analyzer based on specular reflection of an Ir crystal. We can confirm a loss of the *classical* magnetization on a sub-picosecond time scale.

MA 33.10 Thu 11:45 H22

Optically induced ultrafast spin dynamics in Au/Fe/MgO(001) structures: the role of hot carrier transport — •Alexandr Alekhin[1], Damian Bürstel[2], Tim O. Wehling[3], Detlef Diesing[2], Alexander I. Lichtenstein[4], Uwe Bovensiepen[5], and Alexey Melnikov[1] — [1]Fritz-Haber-Institut der MPG, Dep. of Phys. Chem., Berlin, Germany — [2]University of Duisburg-Essen, Insitute of Phys. Chem., Essen, Germany — [3]University of Bremen, Institute of Theor. Phys., Bremen, Germany — [4]University of Hamburg, Institute of Theor. Phys., Hamburg, Germany — [5]University of Duisburg-Essen, Dep. of Physics, Essen, Germany

Spin dynamics (SD) induced by ultrashort laser pulses is of great importance in light of recent advance in spintronics and attempts to control magnetization on femtosecond (fs) time scales. To understand the origin of ultrafast demagnetization, pump-probe experiments have been performed on epitaxial Au/Fe/MgO(001) structures. Using 14 fs laser pulses to probe the Fe side of the samples, we monitor bulk SD by the magneto-optical Kerr effect (MOKE) and SD at interfaces by the magneto-induced second harmonic generation (mSHG). To disentangle interfering mSHG contributions from different interfaces, we have analyzed the dependence of mSHG response on the thickness of Fe film. This approach gives us an access to spatially non-uniform transient magnetization. Comparison of transient mSHG response of Fe to direct optical excitation with that to excitation by hot carriers (HC) generated in Au reveals a significant contribution of spin polarized HC transport to ultrafast demagnetization.

MA 34: Surface and Interface Magnetism II (jointly with O)

Time: Thursday 10:30–13:00 Location: H33

MA 34.1 Thu 10:30 H33

Deviation from Coulombic behavior in short-range interactions of atoms on the GaAs(110) surface — •David Gohlke[1,2] and Jay Gupta[1] — [1]Ohio State University, Columbus, OH USA — [2]Universität Regensburg, Regensburg, Germany

Mn-doped GaAs is a prototypical dilute magnetic semiconductor where substitutional Mn act as electron acceptors while their magnetic moment allows for long-range magnetic interactions. By using low-temperature (5K) scanning tunneling microscopy (STM), we examine the electronic properties of individual Mn dopants in GaAs. We have previously shown that the binding energy of the Mn electron acceptor state can be tuned by controlled atomic-scale placement of a nearby charged defect, and that the shift of the binding energy due to repulsion between the bound hole and these charged defects follows a 1/r Coulombic behavior [Lee and Gupta, Science (2010), Gohlke et al., submitted]. Here we will discuss our observations of deviations from the 1/r behavior. First, our data show that the anisotropy of the GaAs(110) surface affects the interaction between Mn acceptors and charged adatoms. Second, for charged defects brought within 2nm of the acceptor, we observe defect-induced band bending that changes the occupancy of a hybridized Mn state located in the valence band, resulting in a turnaround behavior of the measured resonance energy. This research has implications in studying the interactions between atoms in Mn-doped GaAs, a material for which the mechanisms for magnetism are still debated.

MA 34.2 Thu 10:45 H33

Mapping of the spin-resolved band structure of fct cobalt films on Cu(100) — •Christian Tusche[1], Martin Ellguth[1], Alexander Krasyuk[1], Carsten Wiemann[2], Vitaliy Feyer[2], Marten Patt[2], Claus M. Schneider[2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, 06120 Halle, Germany — [2]Forschungszentrum Jülich, 52428 Jülich, Germany

We report on the spin resolved band structure of ultra thin fct cobalt films grown on Cu(100), measured over large volumes in momentum space. Experiments were carried out at the NanoESCA beamline [1] of the Elettra synchrotron. The instrument, consisting of a photoelectron microscope and an imaging energy analyzer, directly maps the parallel momentum component of photoelectrons at a fixed energy. An imaging spin filter, based on the reflection of low energy electrons at a W(100) crystal, was installed temporarily at the exit of the energy filter [2]. This allowed to record the spin polarization at $4 \cdot 10^3$ discrete reciprocal space points, in each momentum image. This efficient approach gives direct access to majority and minority spin bands in the Fermi surface and their dispersion towards larger binding energies. Using 40 eV to 200 eV photons, several constant energy cuts in the 3D Brillouin zone are selected. The comprehensive data sets are expected to serve as valuable input for advanced concepts in theory for the refined treatment of spin-dependent electron correlation. — [1] Wiemann, Patt, Krug, Weber, Escher, Merkel, Schneider, e-J. Surf. Sci. Nanotech. **9**, 395 (2011) — [2] Tusche, Ellguth, Ünal, Chiang, Winkelmann, Krasyuk, Hahn, Schönhense, Kirschner, Appl. Phys. Lett. **99**, 032505 (2011)

MA 34.3 Thu 11:00 H33

Investigation of the Si/Fe interface with standing-wave excited HAXPES — •Sven Döring[1], Michael Voigt[2], Martina Müller[2], Mihaela Gorgoi[3], Daniel E. Bürgler[2], and Claus M.

Schneider[1,2] — [1]Experimentalphysik, Universität Duisburg-Essen, Lotharstr. 1, 47057 Duisburg — [2]PGI-6, Forschungszentrum Jülich, 52425 Jülich — [3]Helmholtz Zentrum Berlin für Materialien und Energie, Albert Einstein Str. 15, 12489 Berlin

The interface between the ferromagnet Fe and the semiconductor Si is supposed to be a crucial part of future spintronic devices. The possible formation of silicides and the degree of an intermixing between the layers at the interface has a large influence on the conductance and efficiency of spin-injecting currents from the metal layer into the semiconductor. Therefore, we studied the interface between thin MBE-grown layers of Si on Fe with standing-wave excited hard x-ray photoemission spectroscopy. This method gives us a chemically sensitive depth-profile of the sample with a depth-resolution of a few Å and we are able to compare the interface structure of samples that were grown under different conditions.

The Si/Fe sample systems were grown on top of multilayer mirrors that give rise to a high reflectivity and thus to strong modulations of the HAXPES signals. The Fe layer was grown as a wedge which enables us to perform rocking-curve experiments as well as so-called Swedge scans.

MA 34.4 Thu 11:15 H33

Inverse proximity effects in superconductor/ferromagnet bilayer explored by polarized neutron reflectometry — •Yury Khaydukov[1], Bela Nagy[2], Jung-Hwa Kim[1], Thomas Keller[1], Laszlo Bottyan[2], and Bernhard Keimer[1] — [1]Max-Planck Institute for Solid State Research, Stuttgart, Germany — [2]Wigner Research Centre for Physics, Budapest, Hungary

The inverse proximity effect, i.e. the appearance of magnetic correlations in the superconductor (S) close to the interface with a ferromagnet (F) was first considered theoretically in early 2000s. The origin of this effect is the exchange coupling of free (itinerant) electrons near the S/F interface. The spin up electron of a Cooper pair would prefer to be located in ferromagnetic region while spin down electrons would remain in the superconducting region This leads to the development of a magnetic sublayer within the S layer close to the interface with its magnetization antiparallel to the magnetization of free electrons of F layer Me. Thickness of the sublayer is comparable with the superconducting coherence length, ξ. We studied the effect using different methods including transport measurements, SQUID magnetometry etc. However, the main method which allowed us to get the information about the thickness of proximity induced magnetic sublayer was Polarized Neutron Reflectometry . Dependence of this effect (sign and size) on the temperature, coherence length of the S layer ξ, exchange coupling strength of the F layer will be discussed in details.

MA 34.5 Thu 11:30 H33

Spin-density wafe node on antiferromagnetic Cr(110) islands — •Tobias Mauerer[1], Pin-Jui Hsu[1], Weida Wu[2], and Matthias Bode[1] — [1]Institute of Experimental Physics II, University Würzburg, Am Hubland, 97074 Würzburg — [2]Department of Physics and Astronomy and Rutgers Center for Emergent Materials, Rutgers University, Piscataway, New Jersy 08854, USA

We have performed a detailed analysis of the evolution of the charge-density wave (CDW) on the surface of nanoscale Cr islands grown on W(110). By combining conventional spin-averaged and spin-polarized scanning tunneling microscopy (SP-STM) we show that the CDW wavelength exhibits a striking thickness dependence. In particular, the CDW wavelength along the surface $[1\bar{1}0]$ direction increases by about 30% as the island thickness is decreased from about 50 nm to 5.2 nm. A gap with no CDW visible at the island surface appears for films within the thickness range of $3.7 \leq \Theta \leq 5.2$ nm. At even lower film thickness the CDW reappears until it vanishes at $\Theta \leq 2.5$ nm By applying SP-STM we show that the Cr surface is non-magnetic within the CDW gap. The CDW gap and the thickness dependence is explained in terms of a reorientation of the SDW vector $\mathbf{Q}$, which rotates from bulk-like $\langle 001 \rangle$ directions into the [110] surface normal. We propose that the SDW pins with a node at the island surface, resulting in a vanishing surface magnetic moment.

MA 34.6 Thu 11:45 H33

Scanning tunneling microscopy and spectroscopy of MnPc on noble metal (111) surfaces — •Jens Kügel, Jeannette Kemmer, Pin-Jui Hsu, and Matthias Bode — Institute of Experimental Physics II, University Würzburg, Germany

The growth, electronic structure, and magnetic excitations of transition metal phthalocyanine (TM-Pc) molecules adsorbed on noble metal fcc(111) substrates have recently attracted considerable interest. While phthalocyanines with a central ion consisting of Fe, Co, Ni, and Cu have already been studied extensively, only few studies deal with MnPc, even though this molecule carries the highest net magnetic moment in the gas phase ($S = 3/2$) [1]. This property makes it a promising candidate for the observation of collective interaction phenomena with the substrate, such as the Kondo effect. In this contribution we present low-temperature ($T = 5$ K) scanning tunneling microscopy and spectroscopy data of Mn-Pc adsorbed on Au(111) and Cu(111). The tunneling spectra of Mn-Pc show a distinctly asymmetric conductance around the Fermi level. Our results indicate that this feature critically depends on the chemical state of the tip. By systematically modifying the coupling strength between the molecule and the substrate we will discuss under which conditions the Kondo effect can be observed.

[1] A. Stróżecka *et al.*, Phys. Rev. Lett. **109**, 147202 (2012)

MA 34.7 Thu 12:00 H33

Spin-resolved measurements of single molecular magnets on graphene — •Jens Brede, Maciej Bazarnik, Régis Decker, Jörg Schwöbel, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, 20355 Hamburg, Germany

The use of magnetic molecules opens a gateway to a flexible design of novel spintronic devices to store, manipulate, and read spin information at the nanoscale. Crucial is the precise knowledge of molecular properties at the interface towards an electrode. Progress in this field relies on resolving and understanding the physics at the relevant interfaces. In particular the role of individual molecular constituents and the impact of the atomic environment on molecular properties, determine device relevant parameters, such as conductance and spin polarization. Recently, the incorporation of a graphene sheet to electronically decouple molecules from a ferromagnetic surface was addressed by surface averaging techniques.

Here, we applied spin-polarized scanning tunneling microscopy to resolve the physics of the molecule-graphene-ferromagnet interface. The analysis focuses on different phthalocyanine molecules adsorbed on cobalt intercalated graphene on Ir(111). The phthalocyanine constitutes of an organic macrocyclic ligand and can be functionalized with various metal ions in order to modify, e.g. the molecular spin state. We will discuss the spin-dependent transport from magnetic surfaces through such molecules. In particular, the spin polarizations of molecular frontier orbitals are resolved with sub-molecular spatial resolution and the variations in the lifetimes of different states are discussed.

MA 34.8 Thu 12:15 H33

Chemically programmable 2D electron spin arrays — Christian Wäckerlin[1], •Jan Nowakowski[1], Shi-Xia Liu[2], Michael Jaggi[2], Jan Girovsky[1], Dorota Siewert[1], Aneliia Shchyrba[3], Tatjana Hählen[1], Armin Kleibert[1], Peter M. Oppeneer[4], Frithjof Nolting[1], Silvio Decurtins[2], Thomas A. Jung[1], and Nirmalya Ballav[5] — [1]Paul Scherrer Institute, Switzerland — [2]University of Bern, Switzerland — [3]University of Basel, Switzerland — [4]Uppsala University, Sweden — [5]Institute of Science Education and Research, Pune, India

Spin-bearing metal-organic complexes on ferromagnetic substrates are interesting model-systems which allow studying the magnetism of individual magnetic ions in the proximity of a ferromagnetic metal. In our most recent work we have employed synthetically directed self-assembly to fabricate a highly ordered, two-dimensional chessboard-like supramolecular structure of Fe and Mn building-blocks which is exchange-coupled to a suitable ferromagnetic substrate. On-surface coordination-chemistry is then used to selectively control the spin-states in the resultant Fe-Mn-Fe spin-array. We have combined Scanning Tunneling Microscopy (STM) and X-ray Magnetic Circular Dichroism (XMCD) experiments which provide local/spatially averaged and element-specific information, respectively. High resolution STM also yields direct visualization of the axial ligands at the phthalocyanine cores.

MA 34.9 Thu 12:30 H33

Modifying the magnetic properties of adsorbed spin bearing porphyrins by chemical stimuli — •Jan Girovsky[1], Christian Wäckerlin[1], Kartick Tarafder[2], Jan Nowakowski[1], Dorota Siewert[1], Tatjana Hählen[1], Aneliia Shchyrba[3], Armin Kleibert[1], Frithjof Nolting[1], Thomas A. Jung[1], Peter M. Oppeneer[2], and Nirmalya Ballav[4] — [1]Paul Scherrer Institut,

Switzerland — [2]Uppsala University, Sweden — [3]Universtity of Basel, Switzerland — [4]Indian Institute of Science Education and Research (IISER-Pune), India

Metalloporphyrins adsorbed on and exchange coupled to ferromagnetic substrates [1], have been stimulated by different axial ligands like NO and NH3. Beyond the modification of the electronic states in the ad-molecule by the chemical ligation [2], we now focus on the sign and strength of the exchange interaction with the substrate [3,4]. In our experimental (XMCD, STM, XPS) and theoretical (DFT+U) work we provide evidence for cooperativity between the axial ligand on top and the surface ligand below the porphyrin ("surface spin trans effect"). We present four magneto-chemical effects: reduction (HS → IS), quenching (S ≠ 0 → S=0), flipping ("S > 0" → "S < 0") and induction (S = 0 → S ≠ 0) of magnetic moments in specific ad-porphyrins upon coordination with different chemical ligands.

[1] A. Scheybal et al, Chem Phys Lett 411, 214 (2005).
[2] W. Hieringer et al, J Am Chem Soc 133, 6206 (2011).
[3] C. Wäckerlin et al, Nat Comms 1, 61 (2010).
[4] C. Wäckerlin et al, Chem. Science 3, 3154 (2012).

MA 34.10 Thu 12:45 H33

Structural and magnetic properties of pyridyl and benzonitrile based metal-organic networks — •Tobias R. Umbach[1], Matthias Bernien[1], Claudia Hartmann[1], Alexander Krüger[1], Janina N. Ladenthin[1], Constantin Czekelius[2], Jose I. Pascual[1,3], Katharina J. Franke[1], and Wolfgang Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Institut für Chemie und Biochemie - Organische Chemie, Freie Universität Berlin Takustr. 3, 14195, Berlin, Germany — [3]CIC nanoGUNE Consolider, Tolosa Hiribidea, 76, E-20018 Donostia , San Sebastian, Spain

Metal-organic networks offer the possibility to tune the electronic and magnetic functionality of surfaces on a nanometer scale. Here we use LT-STM to characterize the structure of metal-organic networks of transition metal atoms (Co, Fe) and triangular organic linkers, which exhibit either three pyridyl or three benzonitrile endgroups on Au(111). In the case of benzonitrile endgroups, the mixture with transition metal atoms leads to the formation of self-assembled ordered networks with a honeycomb structure. Every transition metal atom is surrounded by three benzonitrile groups forming three-fold coordination nodes. By changing the endgroups to pyridyl, the coordination motif changes significantly. The transition metal atoms exhibit the same in-plane coordination scheme with an additional molecule centered on top. The magnetic properties of the networks are investigated by XMCD measurements, which reveal that, despite their different structures, they all exhibit sizable magnetic moments and magnetic anisotropy.

MA 35: Magnetic Oxides and Shape Memory Alloys (jointly with MM)

Time: Thursday 9:30–11:45 Location: H23

MA 35.1 Thu 9:30 H23

Magnetoelastic coupling and the formation of adaptive martensite in magnetic shape-memory alloys — •Markus Ernst Gruner and Peter Entel — Faculty of Physics and CeNIDE, University of Duisburg-Essen, 47048 Duisburg

Efficient magnetic shape-memory alloys undergo a thermoelastic martensitic transformation which is frequently accompanied by structural premartensitic precursor phenomena. The premartensites evolve into modulated martensitic phases which can in several cases be interpreted as nanotwinned representations of the low-symmetry ground state with a more or less regular periodicity of the twin defects. Their presence is related to a pronounced shear anomaly in [110] direction. This is a common signature of magnetic shape memory systems as different as Ni-Mn-based Heusler systems and disordered fcc Fe-based alloys and can be ascribed to an electronic band-Jahn-Teller-type instability which affects the transversal acoustic phonons in [110] direction.

By means of large-scale first-principles total energy calculations, we will demonstrate at the example of Ni-Mn-based Heusler compounds and disordered Fe-Pd alloys, that the presence of a specific magnetic order is an important factor for the (de-)stabilization of nanotwinned or modulated martensites according to the inherently strong magnetoelastic coupling in these systems.

MA 35.2 Thu 9:45 H23

First order ferromagnetic to antiferromagnetic transition in the Heusler compounds Fe2MnGa and Mn2PtGa — •A. K. Nayak[1], C. Shekhar[1], T. Gasi[2], M. Nicklas[1], and C. Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany. — [2]Institut for Inorganic and Analytical Chemistry, Johannes Gutenberg University, 55099 Mainz, Germany

The discovery of ferromagnetism by Heusler in X2YZ based materials that consist of all nonmagnetic elements has led to finding of several new materials with distinguishable properties. However, the structural and magnetic properties of these materials are complex in nature due to the observation of various magnetic as well as structural ordering depending upon the nature of X, Y and Z atoms. The off-stoichiometry X2YZ based materials, where part of the Z atoms are replaced by Y atoms, show a structural transition with strong magneto-structural coupling. Here we will show the observation of first order magnetic to magnetic transition in the Heusler compounds Fe2MnGa and Mn2PtGa. Fe2MnGa crystallizes in a cubic structure with ferromagnetic (FM) ordering that shows large Curie temperature (TC) of 750K. It undergoes a first-order FM to antiferromagnetic(AFM) transition around the room temperature. Mn2PtGa, which crystallizes in tetragonal structure, undergoes a first-order FM to AFM transition around 150K, below the magnetic ordering temperature of 230K. The first-order FM to AFM transition leads to kinetic arrest of the FM to AFM transition. The observation of phase coexistence and field induced irreversibility results in a new phase termed as magnetic glass.

MA 35.3 Thu 10:00 H23

Unusual magnetic anisotropy of the ferromagnetic shape-memory alloy $Ni_{50}Fe_{23}Ga_{27}$ — •Jin-Feng Qian[1,2], Wen-Hong Wang[1], Guang-Heng Wu[1], and Claudia Felser[2] — [1]Institute of Physics, Chinese Academy of Sciences, 100190, Beijing, China — [2]Max Planck Institute for Chemical Physics of Solids, 01187, Dresden, Germany

Unusual magnetic anisotropy of the ferromagnetic shape-memory alloy $Ni_{50}Fe_{23}Ga_{27}$ has been observed. The anisotropy of the austenite becomes very large, even larger than that of the martnsite in ribbon samples. Lowering the temperature from 300 K to 80 K, the saturation field of the austenite is dramatically increased from 200 Oe up to 6 kOe. This high-anisotropy clearly highlights the demagnetization effect of the martensitic transformation. The physical mechanism is attributed to a combined effect coming from the atomic disorder, the premartensitic transformation, and the off-stoichiometric Ga-rich composition of the alloys.

MA 35.4 Thu 10:15 H23

Magnetic dichroism in angular resolved hard X-ray photoelectron spectroscopy from buried magnetic layers. — •Carlos Eduardo Viol Barbosa, Siham Ouardi, Daniel Ebke, Gerhard H. Fecher, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids

The high bulk sensitivity of hard X-ray photoelectron spectroscopy (HAXPES) in combination with circularly polarized radiation enables the investigation of the magnetic properties of buried layers. Angular distributions of high kinetic energy (7 to 8 keV) photoelectrons in a range of about 60° were recorded in parallel to the energy distribution. Depending on purpose, energy and angular resolutions of 150 to 250 meV and 0.17° to 2° can be accomplished simultaneously in such experiments. Experiments were performed on exchange-biased magnetic layers covered by thin oxide films. More specifically, the angular distribution of photoelectrons from the ferromagnetic layer Co_2FeAl layer grown on MnIr exchange-biasing layer was investigated where the magnetic structure is buried beneath a MgO layer. Pronounced magnetic dichroism is found in the Co and Fe 2*p* states for all angles of emission. A slightly increased magnetic dichroism was observed for normal emission in agreement with theoretical considerations.

MA 35.5 Thu 10:30 H23

Impact of oxygen vacancies on the magnetic properties of

$SrCoO_{3-\delta}$ — •Martin Hoffmann[1,2], Vladislav S. Borisov[2], Igor V. Maznichenko[1], Sergey Ostanin[1], Ingrid Mertig[1], Wolfram Hergert[1], and Arthur Ernst[2] — [1]Institute of Physics, Martin Luther University Halle Wittenberg, Germany — [2]Max Planck Institute of Microstructure Physics, Halle, Germany

Experimental studies have shown that the perovskite $SrCoO_{3-\delta}$ with $\delta \leq 0.06$ is a ferromagnetic metal. Due to a small lattice mismatch, this material could be used as an electrode in functional multicomponent systems with ABO_3 structure. Magnetic properties such as the critical temperature and the magnetic moment obtained in several measurements vary between 210-305K and 1.5-3μ_B, respectively. Former theoretical investigations of this material still lack a proper description of the magnetic properties of $SrCoO_{3-\delta}$. Furthermore, oxygen vacancies are not considered previously. We explain the experimental results from the *ab-initio* point of view using a Korringa-Kohn-Rostoker (KKR) Green function method.

By means of the coherent-potential approximation, we model different amounts of randomly distributed oxygen vacancies and investigate the behavior of the Curie temperature T_C. Although the absolute values for T_C are too large, the gradient agrees well with experiments. To improve the absolute values, we considered the strongly correlated character of the *d*-orbitals of Co by applying the LDA+U method.

MA 35.6 Thu 10:45 H23

Designing magnetic functionality in spin filter oxides on silicon — •Christian Caspers[1], Sebastian Flade[1], Mihaela Gorgoi[2], Andrei Gloskovski[3], Wolfgang Drube[3], Claus M. Schneider[1], and Martina Müller[1] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich — [2]BESSY II, Helmholtz-Zentrum Berlin — [3]DESY Photon Science, DESY Hamburg

Integrating the magnetic oxide functionality into spintronics devices is an appealing route for realizing highly efficient and conductance-matched spin filter contacts. Europium Oxide (EuO) is the only binary magnetic oxide (MO) predicted to be thermodynamically stable on silicon. We succeeded in integrating high-quality EuO thin films directly on Si(001). We performed a depth-sensitive hard x-ray photoemission (HAXPES) study to selectively probe the bulk EuO and EuO/Si interface electronic structure. A quantitative analysis of the Eu core-level photoemission spectra reveals a nearly ideal stoichoimetry of ultra-thin EuO/Si(001) films (d=4 nm) and a fully homogeneous cation distribution. A careful inspection of the Si2p core level provides insights into the chemical state of the EuO/Si interface. An in situ passivation of SiO2 in the monolayer regime reduces metallic silicides at the EuO/Si interface to less than 3 A. Moreover, an epitaxial growth is realized in these carefully designed MO/Si heterostructures. Our study demonstrates the successful integration of high-quality EuO thin films directly on silicon, paving the way for future spin injection applications.

MA 35.7 Thu 11:00 H23

XAS Studies on All-Oxide Ferromagnetic/Ferroelectric Heterosystems: SrTiO3(001)/La0.7Sr0.3MnO3/BaTiO3 — •Hatice Doganay[1], Ingo Krug[1], Jürgen Schubert[2], Daniel Gottlob[1], Florian Nickel[1], Stefan Cramm[1], and Claus M. Schneider[1] — [1]Peter Grünberg Institut (PGI-6) Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Peter Grünberg Institut (PGI-8) Forschungszentrum Jülich, 52425 Jülich, Germany

It is predicted by ab-initio calculations, that there is a charge redistribution at the Fe/BaTiO3 (BTO) [Sahoo, S. et al. PRB 76 (2007) 092108] interface, which is induced by the ferroelectric polarization, changing the interfacial magnetization of the ferromagnet. Considering the theoretical predictions [Burton, J. D. and Tsymbal, E.Y., PRB 80 (2009) 174406], it is very important to improve our knowledge of the interface properties of these so called artificial multiferroics. To avoid uncontrolled oxidation of the metal layer, we use fully oxidic systems such as BTO/La0.7Sr0.3MnO3(LSMO) layered heterostructures. The present work represents an x- ray absorption spectroscopy study on the all-oxide ferromagnetic /ferroelectric heterosystem SrTiO3(001)/LSMO/BTO fabricated by pulsed laser deposition. To provide accurate information on differences in the electronic properties as a function of oxygen background pressure during BTO growth, XAS measurements with polarized x-rays have been performed.

MA 35.8 Thu 11:15 H23

Interface reaction in LSMO-metal hybrid structures — •Nico Homonnay[1], Christian Eisenschmidt[1], Martin Wahler[1], Jo Verbeeck[2], Gustav Van Tendeloo[2], and Georg Schmidt[1] — [1]Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Germany — [2]University of Antwerp, Antwerpen, Belgium

The ferromagnetic oxide $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) is expected to have a high spin polarization. It can thus be interesting for oxide-metal hybrid structures for spintronics applications [1]. In these structures, however, possible degradation of the crystalline LSMO at interfaces to metals can be of utmost importance for transport structures based on giant magnetoresistance or tunnelling magnetoresistance. Here we present a study of in-situ prepared interfaces between LSMO and various metals. LSMO films are grown by pulsed laser deposition. The samples are then transferred in UHV either into a sputtering chamber or into an evaporation system where a thin metal layer is deposited (gold, platinum, copper, tantalum, chromium or titanium). Structural characterization is done by X-ray diffraction and transmission electron microscopy, while the magnetic properties are determined using a SQUID VSM. For a number of metals we observe a strong degradation of the crystalline quality or even a complete loss of crystallinity. In these samples also the magnetization is lost almost completely. Only for noble metals like Au or Pt both magnetic and structural integrity is preserved. These interface reactions are not observed if the sample is left in air for several days prior to metal evaporation. This work was supported by the EU project IFOX. [1] Park et al., Nature 392 (1998)

MA 35.9 Thu 11:30 H23

Photoinduced changes of the first and third harmonic voltage at the metal insulator transition — •Christin Kalkert, Marvin Walter, Jakob Walowski, Manuel Mchalwat, Vasily Moshnyaga, Bernd Damaschke, Markus Münzenberg, and Konrad Samwer — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Manganite compounds are well known for their sensitivity to different external stimuli such as magnetic and electric fields. This is manifested for example in the colossal magnetoresistance and the colossal electroresistance effect. Here we study the influence of laser light on the first and third harmonic voltage in the vicinity of the temperature dependent metal insulator transition. We prepared epitaxial $La_{1-x}Ba_xMnO_3$ films ($x = 0.2 \ldots 0.3$) on $SrTiO_3$ substrates by metalorganic aerosol depostion technique. The first and third harmonic voltages were measured as a function of temperature with and without the laser beam shining onto the manganite bridge. The setup includes two lasers, a continous wave laser (Toptica Photonics, $\lambda = 640$nm) and a femtosecond laser (Femtolaser Fusion, $\lambda \approx 800$nm). We observed a change of the first and third harmonic voltage close to the metal insulator transition under the influence of the laser light. For manganite systems the third harmonic voltage can be associated with the concentration of correlated polarons, hence the results are discussed in terms of a light induced change of the concentration of correlated polarons. Financial support by DFG via SFB 602, TPA2 and the Leibniz Program is acknowledged.

MA 36: Magnetic Measurement Techniques

Time: Thursday 9:30–11:30 Location: H3

Invited Talk MA 36.1 Thu 9:30 H3

Towards single Nanoparticle detection: Element Specific Ferromagnetic Resonance - Microresonators in ScanningTransmission X-ray Microscopy — •Katharina Ollefs — ESRF, Grenoble, France

Magnetic nanoparticles find manifold applications from biomedicine over magnetic sensors to storage devices. For these applications the static but also the dynamic properties are important as for example the magnetic anisotropy energy is a key parameter determining the magnetic hardness and with that the thermal and temporal stability of the individual nanoparticle. These properties vary from particle to particle, for example, due to surface effects resulting from slightly

different morphologies [1]. X-ray detected ferromagnetic resonance (XFMR), a combination of ferromagnetic resonance (FMR) and x-ray absorption spectroscopy (XAS) offers the unique possibility to study the static and dynamic spin and orbital magnetic moments and the magnetocrystalline anisotropy with elemental specificity. In this work XFMR is pursued combining the local resolution of a transmission x-ray microscope [2] with microresonators. These microresonators allow to measure FMR on nanosized objects by enhancing the filling-factor and therefore pave the way for XFMR measurements of nanoparticles.

This work is done in collaboration with A. Ney, R. Meckenstock, D. Spoddig, Ch. Schöppner, H. Ohldag and M. Farle.

[1] F. Kronast, N. Friedenberger, K. Ollefs, et al., Nano Lett. 11, 1710 (2011) [2] D. Zhu, et.al; Phys. Rev. Lett. 105, 043901 (2010)

MA 36.2 Thu 10:00 H3

Characterization of graphene micro Hall-Probe magnetometers — •Philipp Weber, Wolfgang Kroener, Michael Enzelberger, Klaus Gieb, and Paul Müller — Lehrstuhl für Experimentalphysik, Universität Erlangen, Germany

Due to its low charge carrier concentration and low dimensionality graphene is a promising candidate for high-sensitive Hall probes. We have produced Hall bar structures from commercially available CVD-graphene by means of electron beam lithography and oxygen plasma etching. Charge carrier concentration and mobility confirm the high quality of these devices. We were able to produce Hall probes with properties comparable to standard 2DEG GaAs Hall probes. Angular resolved magnetotransport measurements at magnetic fields up to 14 T and temperatures down to 300 mK are presented. We discuss in detail various parameters influencing the basic sensitivity for measuring magnetic moments. As a proof of concept we have performed magnetization measurements of several reference materials.

MA 36.3 Thu 10:15 H3

Multi-Segmented Delayline Detector: A new Data Acquisition Strategy for FEL and Other Timing Experiments — •P. Luschchyk[1], A. Oelsner[2], D. Kutnyakhov[1], A. Fognini[3], Y. Acremann[3], A. Vaterlaus[3], V. Rybnikov[4], and G. Schönhense[1] — [1]Johannes Gutenberg-Universität, Institut für Physik, D-55099 Mainz — [2]Surface Concept GmbH — [3]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland — [4]FLASH, DESY, Hamburg

High-brilliance but low-repetition-rate sources like free electron lasers require new strategies of particle detection because many events have to be registered within one pulse. In this contribution we describe the design parameters and performance of a novel multi-segmented delayline detector (DLD). It consists of an array of 16x9=144 discrete anodes, where the 16 columns are read out by a 16-channel DLD electronics unit, whereas the 9 rows are separated by delayline coupling. The readout of each channel is designed such that all 9 in a row can register simultaneously a hit, thus all 144 anodes can register hits in parallel. The dead time of the detector is as short as 80 ns. This approach increases the detection efficiency by more than an order of magnitude (limited by Poisson statistics) in comparison to the standard DLD [1]. Data acquisition is based on LINUX and integrated in FLASH DAQ system to transfer all results synchronously per macrobunch. [1] A. Oelsner et al., Rev. Sci. Instrum. 72, 3968 (2001) Project funded by BMBF (05K12UM2)

MA 36.4 Thu 10:30 H3

Magneto-optical response of embedded permalloy thin film structures on Si and ZnO substrates investigated by vector-magneto-optical generalized ellipsometry — •Rajkumar Patra[1], Santanu Ghosh[1], Nan Du[2], Danilo Bürger[2,3], Ilona Skorupa[3], Roland Mattheis[4], Jeff McCord[5], Oliver G. Schmidt[2,6], and Heidemarie Schmidt[2] — [1]Indian Institute of Technology Delhi, Department of Physics, 110016 Delhi — [2]Faculty of Electrical Engineering and Information Technology, University of Technology Chemnitz, 09107 Chemnitz — [3]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf — [4]Institute für Photonische Technologien e.V., 07702 Jena — [5]Institute of Materials Science, University of Kiel — [6]Institute for Integrative Nanosciences, IFW Dresden, 01609 Dresden

We investigated the magneto-optical coupling in nominal 5, 10, and 20 nm thick permalloy (Ni81Fe19) thin films embedded in a 3 nm thick Ta and a 3 nm thick Ru layer on Si and on ZnO substrates in the spectral range from 300 to 1100 nm by Mueller matrix ellipsometry measurements in a magnetic field of arbitrary orientation and magnitude up to 400 mT at room temperature [1]. The extracted magnetooptical coupling does not depend on the film thickness [2] and can be used to predict the magnetooptical response for differently designed Ru/permalloy/Ta/Si and Ru/permalloy/Ta/ZnO multilayer samples. [1] K. Mok, N. Du, H. Schmidt, Rev. Sci. Instrum. 82 (2011); [2] K. Mok, J. McCord et al., J. of Appl. Phys. 110 (2011) & Phys. Rev. B 84 (2011).

MA 36.5 Thu 10:45 H3

The role of space charge in spin resolved photoemission experiments — •Gerard Salvatella[1], Andreas Fognini[1], Florian Sorgenfrei[2], Martina Dell'Angela[3], Martin Beye[2], Florian Hieke[3], Andrea Eschenlohr[2], Sanne de Jong[4], Roopali Kukreja[4], Natalia Gerasimova[5], Joerg Raabe[6], Christian Stamm[3], Urs Ramsperger[1], Hermann Dürr[4], Joachim Stöhr[4], Alexander Föhlisch[2], Wilfried Wurth[3], Andreas Vaterlaus[1], Thomas Michlmayr[1], and Yves Acremann[1] — [1]Laboratorium für Festkörperphysik, ETH Zürich, Schweiz — [2]HZB Berlin, Deutschland — [3]Institut für Experimentalphysik, Universität Hamburg, Deutschland — [4]SLAC, Stanford, USA — [5]DESY, Hamburg, Deutschland — [6]PSI, Villigen, Schweiz

Spin resolved photoemission from a solid is one of the most direct ways of measuring the magnetization. If the whole valence band is probed the measured average spin polarization is only weakly dependent on electronic excitations of the solid and represents therefore the magnetization of the sample. Here we present an experiment where the magnetization is measured by spin resolved photoemission of the cascade electrons from a thin Iron film. The sample is exposed to the radiation of the free electron laser (FEL) FLASH in Hamburg. The measured spin polarization depends on the fluence of the FEL radiation: Higher FEL fluence reduces the measured spin polarization. Space charge simulations show the most likely cause of this effect: Space charge of the electron cloud leaving the sample selectively suppresses the emission of lower energy photoelectrons which carry the largest spin polarization.

MA 36.6 Thu 11:00 H3

Resonant magnetic scattering at magnetic domains in Co/Pt multilayers using laser-generated XUV light — •Christian Weier[1,2], Roman Adam[1,2], Dennis Rudolf[1,2], Patrik Grychtol[4], André Kobs[3], Gerrit Winkler[3], Robert Frömter[3], Hans Peter Oepen[3], Margaret M. Murnane[4], Henry C. Kapteyn[4], and Claus M. Schneider[1,2] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, 52425, Jülich, Germany — [2]JARA, Fundamentals of Future Information Technology — [3]Institut für Angewandte Physik, University of Hamburg, 20355, Hamburg, Germany — [4]Department of Physics and JILA, University of Colorado, Boulder, CO 80309-0440, USA

Laser-driven higher-harmonic generation (HHG) has recently been used for element-selective probing of magnetization dynamics in ferromagnets with a femtosecond temporal resolution. Tuning the energy of the probe beam to the M-absorption edges of Fe, Co and Ni located at 52 eV, 61 eV and 67 eV results in a resonant enhancement of the magneto-optic signal. On the other hand, the corresponding wavelength of approximately 20 nm from this tabletop source gives access to a variety of imaging techniques with unique features that are characteristic for a laser source, namely, a low divergence, high coherence and a high temporal resolution. In our small-angle resonant magnetic scattering experiment we employ laser-generated XUV radiation for investigations of Co/Pt-multilayers containing a magnetic, out-of-plane domain pattern. The resulting image in k-space is directly related to the average domain size in the multilayer of approximately 100 nm.

MA 36.7 Thu 11:15 H3

Quantitative magnetic force microscopy with out-of-plane and in-plane sensitivity — •Christopher Friedrich Reiche[1], Thomas Mühl[1], Silvia Vock[1], Volker Neu[1], Albrecht Leonhardt[1], Ludwig Schultz[1,2], and Bernd Büchner[1,2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung IFW Dresden — [2]Institut für Festkörperphysik, Technische Universität Dresden

Magnetic force microscopy (MFM) is a powerful tool for mapping the spacial distribution of one component of the stray field gradient above a magnetic sample surface. We use iron filled carbon nanotubes (FeCNT) as monopole-like magnetic tips that can be easily calibrated [1] to make quantitative MFM possible.

In standard MFM only the out-of-plane stray field component is detected. By oscillating the cantilever with a higher flexural mode we are able to measure not only the out-of-plane component but also the in-plane component with the same sensor [2].

In our recent experiments we improved the sensitivity of the in-plane measurement. Furthermore, we characterized the FeCNT sensor in both directions and confirmed the expected isotropic properties with respect to its effective monopole moment. This makes multiple component quantitative MFM possible with a single calibration measurement.

[1] F. Wolny, T. Mühl, U. Weissker, K. Lipert, J. Schumann, A. Leonhardt, and B. Büchner, Nanotechnology 21, 435501 (2010)

[2] T. Mühl, J. Körner, S. Philippi, C. F. Reiche, A. Leonhardt, and B. Büchner, Appl. Phys. Lett. 101, 112401 (2012)

MA 37: Focus Session: Organic Materials for Spintronics: From Spinterface to Devices (jointly with HL, MA, O)

Since the first report of an organic spin valve in 2004, novel devices such as spin-OLEDs (organic light emitting diodes) and spin-OFETs (organic field effect transistors) as well as sensors based on magnetic resonance were developed. This rapid development of the field of organic spintronics is driven by the large spin life time in organic molecules, combined with the large diversity and flexibility of molecular synthesis and technological processing. Despite the tremendous progress, there are still many challenges which must be tackled. On one hand, it is desirable to achieve a computer-aided design for novel molecules that can keep their properties at the interfaces with the spin-injecting electrodes. On the other hand, novel technologies for the fabrication of spin devices and the spin transport properties of various molecules are being tested. Last but not least, the spin injection at spinterfaces, i.e. at the interface between the organic molecules and the ferromagnetic electrodes, is a key factor that still needs to be understood and controlled. This topical session aims to give an overview of the latest developments in the dynamic field of organic spintronics. (Organizers: Martin Aeschlimann, Uni Kaiserslautern; Bernd Büchner, IFW Dresden; Dietrich R. T. Zahn, TU Chemnitz)

Time: Thursday 9:30–13:30 Location: H32

Invited Talk MA 37.1 Thu 9:30 H32

Organic Magnetoresistance: The effect of excitons on charge transport in organic semiconductors — •William Gillin — Queen Mary, University of London, UK

It has been known since 2003 that applying a magnetic field to an organic light emitting diode (OLED) will cause changes in both the light output (efficiency) of a device and the current through the device (organic magnetoresistance or OMR). The observation of this phenomenon has spurred a number of models to explain the observations but these can be classified in to two broad classes: excitonic and bipolaron. As the effect of the magnetic field is to apply a small perturbation to existing spin dependent processes that are affecting charge transport and recombination, the study of OMR provides an interesting new tool for understanding these processes. In this talk I will highlight the recent developments in the study of organic magnetoresistance and illustrate that the effect probably has several components which are all acting in parallel and which can have different signs and magnetic field dependencies. By developing an understanding of the different magnetic field characteristics of different processes we may open a door on to a new way of studying the interactions responsible for the fundamental operation of organic electronic devices.

Topical Talk MA 37.2 Thu 10:00 H32

Metal-phthalocyanines: Materials for molecular spintronics — •Jens Kortus[1], Rico Friedrich[1], Torsten Hahn[1], Claudia Loose[1], and Martin Knupfer[2] — [1]TU Bergakademie Freiberg, Germany — [2]IFW Dresden, Germany

Metal-phthalocyanines (MPc) are very stable and can have different spin states depending on the transition metal ion. In this contribution we will discuss electronic, (magneto)optical and transport properties of MPc in view of possible application in spintronic devices.

In particular a recently investigated layered system of MnPc and F_{16}CoPc shows charge transfer at an interface between two metal phthalocyanines, which is investigated in detail using density functional theory. These results are of importance for the application of such interfaces in organic electronic devices because charge transfer considerably affects the energy level alignment and the transport behaviour of the respective hetero-junction. Since the transfer of charge is also connected to a transfer of spin and the hybrid system has a net spin of $S = 2$, such compounds could also be termed *spin-transfer materials* with future applications in the area of spintronics [1].

[1] S. Lindner, M. Knupfer, R. Friedrich, T. Hahn, J. Kortus Phys. Rev. Lett. 109 (2012) 027601-1/5

Topical Talk MA 37.3 Thu 10:30 H32

Magneto-optical Kerr Effect Spectroscopy of Selected Phthalocyanines and Porphyrines — •Georgeta Salvan[1], Peter Robaschick[1], Frank Lungwitz[1], Michael Fronk[1], Carola Mende[1], Heinrich Lang[1], Rico Friedrich[2], Jens Kortus[2], and Dietrich R.T. Zahn[1] — [1]TU Chemnitz, 09126 Chemnitz, Germany — [2]2TU Bergakademie Freiberg, Freiberg 09596, Germany

Phthalocyanines and porphyrines find nowadays many applications from pigments to organic electronics. Nevertheless, they still have a special charm for fundamental investigations thanks to the large flexibility of their molecular structure. This work focuses on the influence of the molecular spin ground state on the room temperature magneto-optical activity of some phthalocyanines and porphyrins. The films in the typical thickness range between 30 nm and 100 nm were prepared by organic molecular beam deposition in high vacuum. Magneto-optical Kerr effect (MOKE), which is commonly used to study the magnetic properties of inorganic ferromagnetic layers or magnetic nanostructures, is measured here spectroscopically in the region of the Q and B absorption bands of phthalocyanines and porphyrines. From this the magneto-optical Voigt constant is calculated numerically and can be correlated to the electronic properties of the molecules. For instance, the hybridisation of Co3d states with the HOMO π-orbital of CoPc leads to additional features in the magneto-optical spectra compared to e.g. CuPc. The magnitude of the Voigt constant in the Q band is hardly sensitive to the molecular spin, but highly sensitive to the orientation of the molecules with respect to the substrate plane.

Topical Talk MA 37.4 Thu 11:00 H32

Molecular Quantum Spintronics — •Mario Ruben — Institut für Nanotechnologie (INT), Karlsruhe Institut für Technologie (KIT) — Institut de Physique et Chimie (IPCMS); Université de Strasbourg (UdS)

Molecules can be considered as physical Quantum Objects. Magnetic molecules consist of an atomic core of one-to-few open spin ions surrounded by a shell of organic material. At low temperature such molecular spin objects behave as simple, few-level systems.[1,2] Since quantum coherence and stable entanglement of electron spins are extremely difficult to achieve, alternative concepts propose the use of nuclear spins as quantum information carrier. Nuclear spins are extremely well isolated from environment and less prone to decoherence, and the coherent manipulation can be adapted by tailoring the molecular environment. However, although being well isolated from their surroundings, nuclear spins have to be addressed, ideally electronically since complementary with existing technologies. The delicate balance between decoupling of the magnetic molecule for stable coherence and connecting it for read out can be carried out by synthetic engineering of the molecular components. The first example of a completely elec-

tronic read out of a nuclear spin of a lanthanide ion (bearing electron and nuclear spins) embedded in a magnetic molecule TbPc2, was recently reported.[3] [1] M. Urdampilleta et.al. Nature Mater. 10, 502 (2011) [2] J. Schwöbel, et. al. Nature Comms. 2, 1953 (2012) [3] R. Vincent, et. al. Nature 488, 357 (2012)

Coffee break (15 min)

Topical Talk MA 37.5 Thu 11:45 H32

Nanomembrane based electrodes for contacting ultra-thin organic layers — •Carlos Cesar Bof Bufon[1], Celine Vervacke[2], Maria Esperança Navarro Fuente[2], Dominic J. Thurmer[2], Christian Müller[5], Michael Fronk[3], Georgeta Salvan[3], Dietrich R. T. Zahn[3], and Oliver G. Schmidt[2,4] — [1]Brazilian Nanotechnology National Laboratory, CNPEM, PO Box 619, 13083-970, Campinas, Brazil — [2]Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstraße 20, 01069, Dresden, Germany — [3]Semiconductor Physics, Chemnitz University of Technology, Reichenhainerstrasse 70, 09107, Chemnitz, Germany — [4]Material Systems for Nanoelectronics, Chemnitz University of Technology, Reichenhainerstrasse 70, 09107 Chemnitz, Germany — [5]Physics Departament, UFPR, Curitiba, Brazil

One of the main challenges for accessing the electronic properties of ultrathin organic layers (UOL), and consequently their application for future devices, consists of connecting such layers to the external word. Two main problems usually arise by trying to vertically connect UOLs: i) the interdiffusion of metallic atoms into the sub-10nm molecular layers, which leads to the damaging and/or the modification of the final device behavior; ii) the presence of pin-holes across the molecular layer, which is responsible for short circuited junctions. Here we discuss the fundamentals, potentialities and limitations of using rolled up nanomembranes as top electrodes for contacting a variety of UOLs, including self-assembled monolayer's and ultra-thin organic semiconducting layers.

Topical Talk MA 37.6 Thu 12:15 H32

Spinterfaces as microscopic spin traps — •Mirko Cinchetti — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Kaiserslautern, Germany

Interfaces between ferromagnetic materials and organic semiconductors - also known as spinterfaces - constitute an incredibly rich playground in the field of spintronics. For example, spinterfaces have the potential to be implemented as tunable spin filters, which will pave the way to a whole new class of advanced, i.e., actively controlled spintronics devices. The progress in the field of spinterface science depends thus critically on elucidating the still unexplored spin-dependent carrier dynamics at such hybrid interfaces.
We use time-resolved two-photon photoemission to optically pump and probe a hybrid electronic state forming at the prototypical spinterface between cobalt and the organometallic complex tris(8-hydroxyquinolinato)aluminium (Alq3). We generate a transient spin polarization in the hybrid interface state, and follow its behavior in four dimensions: energy, time, spin and momentum. We find that electrons are confined at the Co-Alq3 interface for times in the range of 0.5-1 ps, and that the confining potential is strongly spin dependent. Such spin-dependent trapping behavior elucidates the fundamental microscopic origin of the spin-filtering properties at spinterfaces, which is important for the design of next-generation spintronics devices based on tunable organic spin filters.

MA 37.7 Thu 12:45 H32

ESR study of the magnetic properties of the MnPc – F_{16}CoPc dimer — •Azar Aliabadi, Susi Linder, Martin Knupfer, Yulia Krupskaya, Vladislav Kataev, and Bernd Büchner — IFW Dresden, 01069 Dresden

Photoemission spectroscopy has demonstrated a charge transfer at the interface between two transition metal phtalocyanines (MnPc and F_{16}CoPc) indicating the formation of a $MnPc^{\delta+}/F_{16}CoPc^{\delta-}$ heterojunction [1]. In this work, the MnPc-F_{16}CoPc dimer system with charge transfer was investigated using ESR spectroscopy at different temperatures. Comparison between ESR spectra of the parent compounds (MnPc and F_{16}CoPc powders) and of the product of the reaction (MnPc/F_{16}CoPc mixed powder) has revealed characteristic features due to the formation of the MnPc – F_{16}CoPc dimer. We discuss distinct magnetic properties of the MnPc – F_{16}CoPc dimer and their possible relation to the charge transfer in the studied complex.

[1] S. Lindner, M. Knupfer, R. Friedrich, T. Hahn, and J. Kortus, *Phys. Rev. Lett.* **109**, 027601 (2012).

MA 37.8 Thu 13:00 H32

Influence of surface interaction on the properties of single-molecule-magnets — •David Klar[1], Andrea Candini[2], Bernhard Krumme[1], Loic Joly[3], Svetlana Klyatskaya[4], Jean-Paul Kappler[3], Mario Ruben[3,4], and Heiko Wende[1] — [1]Fakultät für Physik und CENIDE, Universität Duisburg-Essen — [2]Centro S3 Modena, Istituto Nanoscienze - CNR — [3]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg — [4]Institute of Nanotechnology, Karlsruhe Institute of Technology

Due to the consecutive downsizing of devices, single-molecule-magnets as building blocks for spintronic applications are of high interest for actual research. The remanent behavior, caused by the single-ion anisotropy, of $TbPc_2$ molecules in bulk samples at less than 5 K is reported in the literature. Our goal is to investigate and to understand the influence of the surface on the properties of the $TbPc_2$ molecules deposited onto a substrate. Therefore we study submonolayer coverages of $TbPc_2$ molecules on ferromagnetic surfaces like Ni, and on a very inert surface of highly oriented pyrolytic graphite (HOPG) that should maintain the properties of isolated molecules. By XAS and XMCD we analyze the element specific magnetic and electronic properties. The low interaction with the HOPG surface hardly affects the magnetic properties of the molecules and we were able to observe a remanent magnetization, but only at very low temperatures ($T < 4$ K). On the Ni surface an indirect exchange leads to an antiferromagnetic coupling between the molecules and the surface. As a result, we obtained a remanent magnetization at higher temperatures ($T \approx 100$ K).

MA 37.9 Thu 13:15 H32

Paramagnetic organic radicals on rutile TiO2(110) single crystals — •Reza Kakavandi, Sabine-Antonia Savu, Thomas Chassé, and Maria Benedetta Casu — Institute of Physical and Theoretical Chemistry, University of Tübingen, Germany

A novel class of organic compounds, namely the nitronyl nitroxide radicals, has recently gained attention because of its magnetic property. In this work a pyrene-substituted nitronyl nitroxide radical (NitPyn) deposited on well characterized rutile TiO2(110) single crystals has been investigated by using X-ray photoemission spectroscopy (XPS) and near edge X-ray absorption fine structure spectroscopy. The mechanism of molecular adsorption on the well defined surface, the chemical environment at the interface and the electronic structure of thin films are discussed by analyzing the XPS core level signals. The persistence of the paramagnetic character of the molecules is also discussed with respect to the chemisorption on the surface. Our studies clarifies the orientation of the molecule in the thin films as a function of film thickness as well as the influence of the substrate, identifying the fine balance between molecule-molecule and molecule-substrate interactions.

MA 38: Transport: Spintronics, Magnetotransport 1 (jointly with HL&MA)

Time: Thursday 9:30–13:00 Location: H18

MA 38.1 Thu 9:30 H18

A relativistic implementation of the non-equilibrium Green's function formalism for layered systems — •S Wimmer[1], M Ogura[2], H Akai[2], and H Ebert[1] — [1]Department Chemie, Ludwig-Maximilians-Univeristät München — [2]Department of Physics, Graduate School of Science, Osaka University

The non-equilibrium Green's function formalism has been implemented within the Korringa-Kohn-Rostoker (KKR) multiple scattering theory following previous work [1,2]. First results for the transport in layered systems are presented and compared to available results of other

authors [1–3]. Using a fully relativistic approach within the Dirac-formalism allows us to investigate the influence of spin-orbit coupling. This will be discussed for various transport properties including the spin-transfer torque.

[1] C. Heiliger et al., J. Appl. Phys. **103**, 07A709 (2008)
[2] S. Achilles, Ph.D. thesis, Martin-Luther-Universität Halle-Wittenberg (2012)
[3] P. M. Haney et al., Phys. Rev. B **76**, 024404 (2007)

MA 38.2 Thu 9:45 H18

Persistent Spin Helix Conditions in Two-Dimensional Electron and Hole Gases — •Tobias Dollinger, Andreas Scholz, Paul Wenk, John Schliemann, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg

We discuss magnetotransport in systems with nonnegligable cubic in momentum Dresselhaus Spin Orbit Interaction (SOI). The latter has been found responsible for diminishing and shifting the parameter regime where weak localization signatures, attributed to the so called "Persistent Spin Helix"(PSH) symmetry [1,2], are detected in magnetoconductance traces [3]. Building on the electronic results, we present an effective model for the heavy hole band of a confined twodimensional hole gas, where typically SOI terms with cubic structure are relevant. We investigate numerically and analytically the magnetotransport propery of this model, in which we can identify an analogue to the PSH.

[1]J. Schliemann et al., PRL **90** 146801 (2003)
[2] Bernevig et al., PRL **97** 236601 (2006)
[3] Kohda et al., PRB **86** 081306 (2012)

MA 38.3 Thu 10:00 H18

Aharonov-Casher effect in quantum rings: geometric phase shift by in-plane magnetic field — Diego Frustaglia[1], •Henri Saarikoski[2], Klaus Richter[2], Fumiya Nagasawa[3], and Junsaku Nitta[3] — [1]Departamento de Física Aplicada II, Universidad de Sevilla, Sevilla, Spain — [2]Department of Theoretical Physics, Regensburg University, Germany — [3]Department of Materials Science, Tohoku University, Sendai, Japan

We study transport through Rashba spin-orbit coupled quantum rings where the spin-orbit field causes the Aharonov-Casher effect [1, 2]. The ring is subject to an in-plane magnetic field which gives rise to a shift in the geometric phase. We show that the in-plane field allows control of the geometric phase independently from the dynamic phase and without competing with Aharonov-Bohm phases. We use perturbation theory to calculate the resulting phase shift in quasi-1D rings for weak in-plane fields. The resulting phase shift is quadratic in the in-plane field. Numerical Recursive Green's function algorithm is used to study the effect in multi-mode quantum rings and in the case of large in-plane fields. We demonstrate the effect in InGaAs/InAlAs based quantum rings where the Rashba spin-orbit field is modulated by an external gate. As the in-plane magnetic field is increased we find a quadratic phase shift in the Aharonov-Casher effect towards lower spin-orbit fields in good agreement with calculations.

[1] F. Nagasawa, J. Takagi, Y. Kunihashi, M. Kohda, and J. Nitta, Phys. Rev. Lett. 108, 086801 (2012)
[2] K. Richter, Physics 5, 22 (2012).

MA 38.4 Thu 10:15 H18

Quantum Feedback in nuclear spin-assisted electronic transport — •Klemens Mosshamer and Tobias Brandes — Institut für theoretische Physik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin

We investigate theoretically the electronic transport through quantum dot systems that interact with the nuclear environment via the hyperfine interaction. We show that the non-linear dynamics arising due to the hyperfine interaction can be controlled via closed-loop feedback operations, such as time-dependent modifications of the tunneling rate.

MA 38.5 Thu 10:30 H18

Projective Boltzmann approach to thermal drag in spin-1/2-ladder systems coupled to phonons — •Christian Bartsch and Wolfram Brenig — Institute for Theoretical Physics, Technical University Braunschweig, D-38106 Braunschweig

We quantitatively investigate the spin-phonon drag contributions to the thermal conductivity of a two-leg-spin-1/2-ladder coupled to lattice vibrations in a magnetoelastic way. By applying suitable transformations the system is mapped onto a weakly interacting quantum gas model of bosonic spin excitations (magnons) and phonons. We adequately construct a collision term of a linear(ized) Boltzmann equation from the underlying quantum dynamics by means of a pertinent projection operator technique. From the Boltzmann equation we obtain concrete numerical values for the drag conductivity and relate it to the individual thermal conductivities of magnons and phonons for parameter ranges which are typical for certain material classes.

MA 38.6 Thu 10:45 H18

Rashba spin-orbit-interaction-based quantum pump in graphene — •Dario Bercioux[1], Daniel F. Urban[2,3], Francesco Romeo[4], and Roberta Citro[4] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, 79104 Freiburg, Germany — [2]Physikalisches Institut, Albert-Ludwigs-Universität, 79104 Freiburg, Germany — [3]Fraunhofer Institute for Mechanics of Materials IWM, Wöhlerstraße 11, 79108 Freiburg, Germany — [4]Dipartimento di Fisica "E. R. Caianiello" and Spin-CNR, Università degli Studi di Salerno, I-84084 Fisciano (Sa), Italy

We present a proposal for an adiabatic quantum pump based on a graphene monolayer patterned by electrostatic gates and operated in the low-energy Dirac regime [1]. The setup under investigation works in the presence of inhomogeneous spin-orbit interactions of intrinsic- and Rashba-type and allows to generate spin polarized coherent current. A local spin polarized current is induced by the pumping mechanism assisted by the spin-double refraction phenomenon [2].

[1] Citro, Appl. Phys. Lett. **101**, 122445 (2012)
[2] D. Bercioux, A. de Martino, Phys. Rev. B **83**, 012106 (2011)

MA 38.7 Thu 11:00 H18

First-principles calculation of ballistic transport in single-atom contacts — •Fabian Otte[1], Björn Hardrat[1], Frank Freimuth[2], Yuriy Mokrousov[2] und Stefan Heinze[1] — [1]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — [2]Peter-Grünberg-Institut, Forschungszentrum Jülich, 520425 Jülich, Germany

Recently, the spin-valve effect of single-atom contacts has been demonstrated using scanning tunneling microscopy [1]. In these measurements a magnetic tip approaches magnetic adatoms on a surface and the distance-dependent conductance and magnetoresistance is obtained. Here, we report first-principles calculations of ballistic transport in model systems of such single-atom contacts using our recently developed approach [2] which allows to include spin-orbit coupling and non-collinear spin structures. We present the conductance between two ferromagnetic Co monowires terminated by single Mn apex atoms while varying the distance between the two Mn atoms. Due to frustration of exchange interactions a non-collinear spin state is favorable in the contact regime. We show that it leaves a fingerprint in the distance-dependent conductance and magnetoresistance [3]. We also study the ballistic anisotropic magnetoresistance from the tunneling to the contact regime for leads whose structure is modeled with Fe monowires.

[1] M. Ziegler et al., New J. Phys. 13, 085011 (2011)
[2] B. Hardrat et al., Phys. Rev. B 85, 245412 (2012)
[3] B. Hardrat et al., Phys. Rev. B 86, 165449 (2012)

15 min. break

MA 38.8 Thu 11:30 H18

A carbon nanotube quantum dot in the intermediate coupling regime: Conductance and tunnel magnetoresistance — •Alois Dirnaichner, Johannes Kern, and Milena Grifoni — Universität Regensburg

We discuss transport through carbon nanotube quantum dots with intermediate coupling to ferromagnetic leads. In a density matrix approach we sum up infinite-order corrections due to charge fluctuations within the dressed second order approximation (DSO) [1], allowing us to go beyond the sequential tunneling regime. From the master equation we deduce conductance and tunnel magnetoresistance (TMR). The results are compared to experimental data with a pronounced gate modulation of the TMR and negative TMR features in particular.

[1] J. Kern and M. Grifoni, arXiv:1209.4995v1

MA 38.9 Thu 11:45 H18

Spin transport in carbon nanotubes in the Fabry-Perot

regime — •Miriam del Valle and Milena Grifioni — Institute of Theoretical Physics, University of Regensburg

We investigate the spin-dependent transport through carbon nanotubes connected to two ferromagnetic leads in the ballistic regime. The effect and origin of the phases acquired by electrons upon scattering at the contact interfaces are analyzed. These phases greatly determine the Fabry-Perot patterns obtained in this transport regime. With stress on the nanotube fingerprints, the magneto-resistance is calculated with the inclusion of spin-orbit effects, which are not negligible due to the finite curvature of the nanotubes.

MA 38.10 Thu 12:00 H18

Investigation of spin transfer torques in $Mn_{1-x}Fe_xSi$ — •Christoph Schnarr, Robert Ritz, Andreas Bauer, Christian Franz, and Christian Pfleiderer — Technische Universität München, Physik-Department E21, D-85748 Garching, Germany

Small angle neutron scattering and Hall effect measurements recently revealed sizeable effects of spin transfer torques in the skyrmion lattice phase of MnSi [1,2]. The associated critical current densities of $\sim 10^6$ A/m^2, are exceptionally small and about 5 orders of magnitude smaller than the spin transfer torque observed in conventional systems. The low critical current density is due to a very efficient gyromagnetic coupling exhibited by a topological Hall contribution that arises in the topologically non-trivial magnetic structure of a skyrmion lattice. We report spin transfer torque experiments, measuring the Hall effect in $Mn_{1-x}Fe_xSi$ for a wide range of x, where the topological Hall effect increases by up to a factor of ten characteristic of a much more efficient coupling of the electric currents to the magnetic structure. The dependence of j_c on the doping concentration is discussed in view of the increased topological Hall effect as well as the increased pinning by disorder.

[1] F. Jonietz *et al.*, Science **330**, 1648-1651 (2010)
[2] T. Schulz *et al.*, Nat Phys **8**, 4, 301-304 (2012)

MA 38.11 Thu 12:15 H18

Magnetotransport along a boundary: From coherent electron focusing to edge channel transport — •Thomas Stegmann, Dietrich E. Wolf, and Axel Lorke — University of Duisburg-Essen, Department of Physics and CENIDE

In a two dimensional electron system with a boundary, electrons are injected at one point on the boundary and focussed by a perpendicular magnetic field B onto another voltage probe on the boundary. Using the nonequilibrium Green's function approach we study theoretically the 4-point Hall resistance R_{xy} as a function of B. For low fields, R_{xy} shows the characteristic equidistant peaks observed in the experiment, which can also be explained by simple classical trajectories: The electrons are guided on cyclotron orbits, are reflected speculary at the boundary, and end finally at the collector when a multiple of the cyclotron diameter equals the distance between injector and collector. In a strong magnetic field, the current is carried by edge channels parallel to the boundary and the typical fingerprint of the quantum Hall effect is observed. Here, we study the transition from the classical cyclotron motion to the edge channel transport and discuss its influence on the focussing spectrum. In intermediate fields, we find that R_{xy} shows sets of oscillations, which are neither periodic in B (such as the magnetic focussing peaks) nor in $1/B$ (quantum Hall effect). These oscillations can be understood as interference between adjacent edge states.

MA 38.12 Thu 12:30 H18

Entanglement detection in Cooper pair splitters based on carbon nanotubes in magnetic fields — •Pablo Burset[1,2], Bernd Braunecker[1], and Alfredo Levy Yeyati[1] — [1]Departamento de Fisica Teorica de la Materia Condensada, Universidad Autonoma de Madrid, E-28049 Madrid, Spain — [2]Institute for Theoretical Physics and Astrophysics, University of Wuerzburg, Am Hubland, 97074 Wuerzburg, Germany

The production of entangled electron pairs in a solid state device from the splitting of a Cooper pair is currently attracting much attention. Recent experiments have shown that Cooper pairs can be split in a controlled fashion in double quantum dot structures. In this talk I will describe how spin-orbit interaction in carbon nanotubes presents unique characteristics for the study of the entanglement of injected pairs of electrons.

I will briefly introduce the double dot Cooper pair splitter device based on carbon nanotubes. In this setup, I will review the form of spin-orbit interaction and demonstrate that it leads to a perfect spin filter with spin orientations tunable by external fields. Tunable spin-orbit induced spin-filtering allows to implement entanglement detectors, such as probing a Bell inequality. These detectors can rely on conductance measurements alone and do not require the precise knowledge of the spin orientations of the spin filter. Yet if in addition the spin orientations are known, the same setup can be used for full quantum state tomography.

MA 38.13 Thu 12:45 H18

Electronic correlations in magnetic heterostructures. — •Liviu Chioncel[1,2] and Junya Otsuki[2,3] — [1]Augsburg Center for Innovative Technologies, University of Augsburg, D-86135 Augsburg, Germany — [2]Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany — [3]Department of Physics, Tohoku University, Sendai, Japan

Heterostructures that contain semiconducting and magnetic monolayers offer the possibility to adjust simultaneously band-gap and magnetic properties. Dynamical Mean Field Theory is a necessary theoretical tool to address physical properties of multilayer systems containing correlated electrons. Here we solve a simplified Hubbard model within DMFT using the recently developed CT-QMC solver, for several magnetic monolayers embedded into semiconducting/insulating host. Our approach is relevant for the Cr/Mn-doped semiconducting heterostructures. We discuss possible half-metallic properties in these systems in the presence of dynamic correlations at finite temperatures.

MA 39: Focused Session: Magnetism & Superconductivity in Fe-based Pnictides and Chalcogenides (jointly with MA)

Iron-based superconductors and their relation to magnetism is an exciting research field involving condensed matter physics, materials science, and solid state chemistry. In this Focus Session recent advances and results will be presented by leading experts in the field.

Organizers: Joachim Deisenhofer (University of Augsburg), Carsten Honerkamp (RWTH Aachen)

Time: Thursday 9:30–12:45 Location: H20

Invited Talk MA 39.1 Thu 9:30 H20

Fermiology and Order Parameter of Iron-based Superconductors from ARPES — •Sergey Borisenko — IFW Dresden

We use angle-resolved photoemission at ultra-low temperatures (1K-ARPES) to study iron-based superconductors. A number of materials from the 11, 111, 1111, 122, 245 and 1048 families have been studied. In some of them precise measurements of the superconducting gap as a function of momentum allow us to draw conclusions as for the structure and symmetry of the order parameter. In addition, we single out those details of the low-energy electronic structure which are necessary for the superconductivity itself.

[1] S. V. Borisenko et al., arXiv:1204.1316 (2012)
[2] S. V. Borisenko, Synchrotron Radiation News **25**(5), 6 (2012)
[3] S. V. Borisenko et al., J. Vis. Exp. **68**, e50129, DOI: 10.3791/50129 (2012)

Invited Talk MA 39.2 Thu 10:00 H20

Electron Correlations in Solids from the Dynamical Mean Field Perspective and the Origin Anomalous State of Matter in Iron Chalchogenides — •Kristjan Haule — Rutgers The State

University of New Jersey, Piscataway, NJ, USA

The Dynamical Mean Field Theory in combination with the Density Functional Theory has recently enabled detailed modeling of the electronic structure of complex materials such as heavy fermions, transition metal oxides, chalchogenides and arsenides. Simulations based on this method has recently uncovered the origin of unusual properties of iron based high temperature superconductors and the physics behind the poor metallic conductivity in these systems. Here the Coulomb interaction among the electrons is not strong enough to localize electrons, but it significantly slows them down, such that low-energy emerging quasiparticles have a substantially enhanced mass, and at intermediate temperature and intermediate energy scale show strong deviations from the Fermi liquid theory. This enhanced mass emerges not because of the Hubbard interaction U, but because of the Hund's rule interactions J that tends to align electrons with the same spin but different orbital quantum numbers when they find themselves on the same atom. The ab-initio simulations with the Dynamical Mean Field Theory not only uncover the origin of anomalous properties, but also successfully explains the key properties of these material: such as the mass renormalizations and anisotropy of quasiparticles, the crossover into an incoherent regime above a low temperature scale, the magnetic moments in iron compunds, and dispersion of magnetic excitations.

Topical Talk MA 39.3 Thu 10:30 H20

A Light Scattering Study of the Evolution of Pairing in Fe-based Superconductors — •Rudi Hackl[1], Florian Kretzschmar[1], Bernhard Muschler[1], Thomas Böhm[1], Hai-Hu Wen[2], Vladimir Tsurkan[3,4], Joachim Deisenhofer[3], and Alois Loidl[3] — [1]Walther-Meissner-Institut, DE-85748 Garching — [2]Nanjing University, Nanjing 210093, China — [3]University of Augsburg, DE-86159 Augsburg — [4]Academy of Sciences of Moldova, MD-2028 Chisinau

The iron-based superconductors are a laboratory for exploring the relevance of electron-electron interactions beyond electron-phonon coupling, being at work in conventional superconductors, since the Fermi surfaces can be varied systematically by atomic substitution. This enables one to systematically study magnetism and superconductivity as a function of the Fermi surface topology. Inelastic light scattering affords a window into the electronic properties of the ordered states. In particular, the evolution of the superconducting pairing upon doping can be probed since light scattering allows access to the anisotropy of the energy gap and, in some cases, of the pairing potential. $Ba_{1-x}K_xFe_2As_2$ is one of those cases since the competition between *s*- and *d*-wave pairing leads to the appearance of exciton-like modes below the gap edges of the various bands. Along with the results from other materials having different Fermi surface cross-sections the data in $Ba_{1-x}K_xFe_2As_2$ support the spin fluctuation scenario driven by interband coupling. The experiments show that there exist alternative routes for the analysis of the pairing interaction in superconductors with unconventional coupling and anisotropic gaps.

15 min. break

Topical Talk MA 39.4 Thu 11:15 H20

Theory of Magnetism and Superconductivity for Iron-Chalcogenides — •Jiangping Hu — Dept. of Physics, Purdue University, West Lafayette, IN, USA — Institute of Physics, Chinese Academy of Sciences, Beijing, China

We discuss the difference on both magnetic and superconducting properties between iron-pnictides and iron-chalcogenides high temperature superconductors and construct a microscopic model based on S_4 symmetry that faithfully represents the intrinsic unit cell doubling of the materials. Within this model, we can show that there are two different types of extended S-wave pairing states. One is in the A representation of S_4 and the other is in the B representation of S_4. The A-phase is well studied $S_\pm$ phase when there are both electron pockets at M points and hole pockets at Γ point. However, the B phase is the new phase which has been ignored by models with one-iron per unit cell. The B phase is characterized by the sign reverse of the superconducting order parameter in real space between top and bottom layers in the building block of the trilayer Fe-As(Se) structure. We show that the B-phase is most likely realized in the electron-doped 122' or strained single layer iron-chalcogenides.

Topical Talk MA 39.5 Thu 11:45 H20

Charge Dynamics in 122 Iron Pnictides — •Aliaksei Charnukha, Oleg V. Dolgov, Paul Popovich, Dunlu Sun, Chengtian Lin, Alexander Yaresko, Bernhard Keimer, and Alexander V. Boris — Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany

We report the full complex dielectric function of high-purity $Ba_{0.68}K_{0.32}Fe_2As_2$ single crystals with $T_c = 38.5$ K determined by broadband spectroscopic ellipsometry at temperatures $10 \leq T \leq 300$ K. We discuss the microscopic origin of superconductivity-induced infrared optical anomalies in the framework of a multiband Eliashberg theory with two distinct superconducting gap energies, $2\Delta_A \approx 6\ k_BT_c$ and $2\Delta_B \approx 2.2\ k_BT_c$. The observed unusual suppression of the optical conductivity in the superconducting state at energies up to $14\ k_BT_c$ can be ascribed to spin-fluctuation–assisted processes in the clean limit of the strong-coupling regime. We further observe a superconductivity-induced suppression of an absorption band at an energy of 2.5 eV, two orders of magnitude above the superconducting gap energy $2\Delta \approx 20$ meV, which challenges one of the central notions of conventional theories of superconductivity. We argue that the observed superconductivity-induced suppression involves a redistribution of electronic population between bands with different orbital character. Our results emphasize the importance of orbital physics for the mechanism of superconductivity in the iron-based superconductors.

MA 39.6 Thu 12:15 H20

Disentangling Magnetism and Superconductivity in $EuFe_2(As_{1-x}P_x)_2$ — •Sina Zapf[1], Tomislav Ivek[1], Felix Klingert[1], Fabian Pfister[1], Shuai Jiang[1], Dan Wu[1], Hirale S. Jeevan[2], Philipp Gegenwart[2], Reinhard K. Kremer[3], and Martin Dressel[1] — [1]1. Physikalisches Institut, Universität Stuttgart — [2]I. Physikalisches Institut, Universität Göttingen — [3]Chemical Service Group, MPI-FKF Stuttgart

Due to local magnetic ordering of Eu^{2+}, $EuFe_2(As_{1-x}P_x)_2$ is a perfect system to study the interplay between superconductivity (SC) and magnetism in iron pnictides. However, there is still an ongoing debate about the extent of the superconducting dome and the development of the local Eu magnetic ordering with chemical pressure [1,2]. Especially the question whether SC coexists with ferro- (FM) or antiferromagnetic (AFM) Eu^{2+} ordering has drawn tremendous interest.
We have performed a systematic study on a set of high-quality single crystals (x = 0, 0.12, 0.145, 0.15, 0.165, 0.17, 0.26, 0.35 and 1) using DC resistivity, as well as DC and AC magnetic susceptibility measurements along the principal crystallographic directions. By combining these techniques we identify the different phases, prove that AFM interlayer coupling coexists with SC and discuss the complex magnetization behaviour of these compounds. Our investigations reveal the delicate interplay between SC and magnetism.

[1] Jeevan et al., PRB 83, 054511 (2011)
[2] Cao et al., Condens. Matter 23, 464204 (2011)

MA 39.7 Thu 12:30 H20

Growth and characterization of $Rb_{1-x}Fe_{2-y}Se_2$ single crystals — •Vladimir Tsurkan[1,2], Joachim Deisenhofer[1], Axel Günther[1], Hans-Albrecht Krug von Nidda[1], Sebastian Widmann[1], and Alois Loidl[1] — [1]Experimental Physics 5, Center for Electronic Correlations and Magnetism, University of Augsburg, D 86159, Augsburg, Germany — [2]Institute of Applied Physics, Academy of Sciences of Moldova, MD-2028, Chisinau, R. Moldova

Growth of single crystals of Rb-Fe-Se system and their characterization by X-ray powder diffraction, Squid magnetometry, conductivity, and specific heat are presented [1]. The single crystals exhibit an anisotropic antiferromagnetism below 400 K. For $1.53 < Fe < 1.6$ the superconducting (SC) behavior is found. The sharp transition into the SC state at 32.4 K is observed for $Rb_{0.8}Fe_{1.6}Se_2$. For the Fe concentrations below 1.5 and above 1.6, respectively, samples show insulating and semiconducting behavior. Magnetic behavior of SC and non-SC samples provides an evidence for the coexistence of superconductivity and static antiferromagnetic order. The evolution of the SC and AFM correlations in the Rb-Fe-Se system is discussed within the constructed phase diagram which includes several structural phases with different magnetic behavior. The coexistence of the superconductivity and antiferromagnetism in $Rb_{0.8}Fe_{1.6}Se_2$ is considered within a scenario of phase separation based on the results of neutron scattering, Mössbauer spectroscopy, optical, μSR, and nuclear magnetic resonance investigations.

[1] V. Tsurkan, J. Deisenhofer, A. Günther, H.-A. Krug von Nidda, S. Widmann, and A. Loidl, Phys. Rev. B **84**, 144520 (2011)

MA 40: Molecular Magnetism

Time: Thursday 15:00–17:15 Location: H23

MA 40.1 Thu 15:00 H23

Single molecule magnets from magnetic building blocks — •Wolfgang Kroener[1], Alexa Paretzki[2,3], Christian Cervetti[2,4], Stephan Hohloch[3], Stephan Rauschenbach[4], Klaus Kern[4], Martin Dressel[2], Lapo Bogani[2], and Paul Müller[1] — [1]Lehrstuhl für Experimentalphysik, Universität Erlangen — [2]1. Physikalisches Institut, Universität Stuttgart — [3]Institut für Anorganische Chemie, Universität Stuttgart — [4]Max Planck Institut für Festkörperforschung, Stuttgart

We present measurements of a basic set of magnetic building blocks that were rationally assembled, similar to magnetic LEGO bricks, in order to create a huge variety of magnetic behavior[1]. Using rare-earth centers and multipyridine ligands, fine-tuning of intra and intermolecular exchange interaction was demonstrated. We have investigated a series of molecules with monomeric, dimeric and trimeric lanthanide centers using SQUID susceptometry and Hall bar magnetometry. A home-made micro-Hall-probe magnetometer was used to measure magnetic hysteresis loops at mK temperatures and fields up to 17 T. All compounds show hysteresis below blocking temperatures of 3 to 4 K. The correlation of the assembly of the building blocks with the magnetic properties will be discussed.

[1]A. Paretzki et al. Nature Chemistry, submitted

MA 40.2 Thu 15:15 H23

Substrate Dependent Thermal Deposition of $NdPc_2$ Single Molecules — •Sarah Fahrendorf[1,2], Frank Matthes[1,2], Claire Besson[1,2,3], Paul Kögerler[1,2,3], Daniel E. Bürgler[1,2], and Claus M. Schneider[1,2] — [1]Peter Grünberg Institute (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Jülich-Aachen Research Alliance (JARA-FIT), Forschungszentrum Jülich, 52425 Jülich, Germany — [3]Institute of Inorganic Chemistry, RWTH Aachen, D-52074 Aachen, Germany

Single molecule magnets play an important role in the field of molecular spintronics. A relevant class of molecules are the lanthanide double-decker phthalocyanines ($LaPc_2$) with only one metal atom in the center of the two organic phthalocyanine ligands. For envisaged spintronics applications it is important to understand the interaction between the substrate and the molecules and its influence on the electronic properties. Here, we study the substrate dependent deposition characteristics of neodymium double-decker phthalocyanines ($NdPc_2$) by means of low temperature scanning tunneling microscopy and spectroscopy (STM and STS). The $NdPc_2$ molecules were in-situ evaporated from a Knudsen cell on clean metallic surfaces such as Au(111), Cu(100), and Fe(110). It is observed that a significant fraction of the double-decker phthalocyanines decompose into two single-decker phthalocyanine molecules. The decomposition probability is found to be strongly substrate dependent. By means of STS-spectra we find that stronger substrate molecule interaction leads to enhanced charge transfer which strengthens the intramolecular electrostatic bonding.

MA 40.3 Thu 15:30 H23

Exchange-based and single-ion based relaxation of the magnetization in Ni_2Dy — •Alexander Sundt[1], Amin Khan[2], Pascal Wendler[1], Yanhua Lan[2], Annie K. Powell[2], and Oliver Waldmann[1] — [1]Physikalisches Institut, Universität Freiburg, Germany — [2]Institute of Inorganic Chemistry, Karlsruhe Institute of Technologie, Germany

Ever since the discovery of slow relaxation of the magnetization at the molecular scale in Mn_{12}ac scientists focused on increasing the energy barrier for magnetization reversal U_{eff} in order to lift the single molecule magnet (SMM) behaviour from cryogenic to easier accessible temperatures for possible applications. A promising road to increase U_{eff} is the incorporation of highly anisotropic magnetic ions such as rare earth ions in heterometallic SMMs. However, using these ions presents novel challenges such as complicated relaxation pathways.

In this talk we present an experimental study by means of AC and DC susceptibility as well as single crystal magnetization measurements on the 3d4f heterometallic SMM Ni_2Dy. The data show that the blocking mechanism for magnetization reversal undergoes as function of temperature a crossover from an exchange-based to a single-ion based relaxation mechanism. In contrast to the situation in Co_2Dy_2, where we could identify the phenomenon for the first time [1], some significant differences are observed, which will be discussed.

[1] K. C. Mondal, A. Sundt, *et. al.*, Angew. Chem. 124, 7668 (2012)

MA 40.4 Thu 15:45 H23

The role of dysprosium in single-molecule magnets based on mixed metal nitride cluster fullerenes — •Rasmus Westerström[1,2], Jan Dreiser[2], Cinthia Piamonteze[2], Roland Stania[1,2], Fumihiko Matsui[1,3], Stephen Weyeneth[1], Veacheslav Vieru[4], Liviu Ungur[4], Liviu Chibotaru[4], Stefano Rusponi[5], Harald Brune[5], Shangfeng Yang[6,7], Alexey Popov[6], Matthias Muntwiler[2], Lothar Dunsch[6], and Thomas Greber[1] — [1]Physik-Institut, Universität Zürich, Switzerland — [2]Swiss Light Source, Paul Scherrer Institut, Switzerland — [3]NAIST Ikoma, Nara, Japan — [4]Division of Quantum and Physical Chemistry, Katholieke Universiteit Leuven, Belgium — [5]Institute of Condensed Matter Physics, EPFL, Lausanne, Switzerland — [6]Hefei National Laboratory for Physical Sciences at Microscale, Department of Materials Science and Engineering, USTC, China — [7]Department of Electrochemistry and Conducting Polymers, Leibniz Institute of Solid State and Materials Research, Dresden, Germany

So far it was known that the metal nitride cluster fullerenes $Ln_3N@C_{80}$ (Ln = Tb, Ho) are paramagnetic above 1.8 K [1]. Here we report on the first fullerene exhibiting single-molecule magnet behaviour [2]. The magnetism of $DySc_2N@C_{80}$ was studied using x-ray magnetic circular dichroism (XMCD), SQUID, and *ab initio* calculations. SQUID show hysteresis and thermal and nonthermal spin relaxation. In a next step endofullerenes containing more than one Dy ion were investigated.

[1] M. Wolf *et al*, Angew. Chem. Int. Ed. **44**, 3306 (2005).
[2] R. Westerström *et al*, J.Am. Chem. Soc. **134**, 9840 (2012).

15 min. break

MA 40.5 Thu 16:15 H23

Large-scale numerical investigations of the antifderromagnetic Heisenberg icosidodecahedron — Jörg Ummethum[1], Andreas Läuchli[2], and •Jürgen Schnack[1] — [1]Bielefeld University, P.O. box 100131, D-33501 Bielefeld — [2]Innsbruck University, Technikerstr. 25, A-6020 Innsbruck

We present up to date investigations of the antiferromagnetic Heisenberg icosidodecahedron by means of the Density Matrix Renormalization Group method. We compare our results with modern Correlator Product State as well as Lanczos calculations.

J. Ummethum, J. Schnack, A.M. Laeuchli, J. Magn. Magn. Mater. 327 (2013) 103-109

MA 40.6 Thu 16:30 H23

Unconventional Magnetic Properties of the Antiferromagnetic Heisenberg Model on Two Linked Dodecahedra — •Nikolaos P. Konstantinidis — Fachbereich Physik und Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

The antiferromagnetic Heisenberg model has been shown to possess a non-trivial magnetic response in an external field for spins located on the vertices of a dodecahedron [1,2]. Here a first step towards a lattice of dodecahedra is taken by considering two dodecahedra linked along one of their faces with varying exchange coupling. The competition between intramolecular frustration, intermolecular coupling and magnetic field leads to a richer phase diagram compared to the single dodecahedron case. In the case of classical spins, the magnetization response may contain up to six magnetization discontinuities. In the full quantum case $s_i = 1/2$ the states are characterized by the full symmetry of the Hamiltonian, and for weak intermolecular couplings there can be up to two magnetization discontinuities in a field. These discontinuities are unexpected for the antiferromagnetic Heisenberg model, which lacks magnetic anisotropy, and are a direct consequence of the exchange coupling geometry and its competition with the field. These results show the potential for non-trivial magnetic properties in structures build up from dodecahedra.

[1] N. P. Konstantinidis, Phys. Rev. B 72, 064453 (2005).
[2] N. P. Konstantinidis, Phys. Rev. B 76, 104434 (2007).

MA 40.7 Thu 16:45 H23

Huge magnetically coupled orbital moments of Co porphyrin molecules and their control by CO adsorption — •Christian F. Hermanns[1], Kartick Tarafder[2], Matthias Bernien[1], Alex Krüger[1], Waldemar Walter[1], Yin-Ming Chang[1], Eugen Weschke[3], Peter M. Oppeneer[2], and Wolfgang Kuch[1] — [1]Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin, Germany — [2]Department of Physics and Astronomy, Uppsala University, P.O. Box 516, 75120 Uppsala, Sweden — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Straße 15, 12489 Berlin, Germany

We report on a combined experimental-theoretical study of physisorbed Co-porphyrin molecules on a graphene-protected Ni film. By using X-ray magnetic circular dichroism, we show that an antiferromagnetic coupling between the Co and Ni spins is established across graphene. According to density functional theory calculations the coupling is mediated via the π electronic system of graphene. The Co ions, despite their four-fold coordination, reveal a huge measured in-plane orbital moment m_l, even comparable in size to the spin moment. Carbon monoxide adsorption on top of the molecules reduces the Co orbital moment by $(77 \pm 6)\%$ and the entire magnetic moment by $(37 \pm 3)\%$, without modifying the spin state S=1/2. This is attributed to the change of the crystal field by the chemical stimulus, which determines m_l together with the spin-orbit coupling.

This work is supported by the DFG (Sfb 658), the Swedish-Indian Research Link Programme, the C. Tryggers Foundation, and the SNIC.

MA 40.8 Thu 17:00 H23

Quenching the quantum tunneling of magnetization in Mn_6Cr single-molecule magnets — •Klaus Gieb[1], Veronika Hoeke[2], Wolfgang Kroener[1], Thorsten Glaser[2], and Paul Müller[1] — [1]Department für Physik, Universität Erlangen — [2]Department Chemie und Pharmazie, Universität Bielefeld

We report on low-temperature magnetic measurements of Mn_6Cr^{3+} single molecule magnets with different counter ions and crystal structures [1]. From SQUID susceptibility measurements it can be concluded that the ground state spin for these molecules is $S_t = 21/2$. Ac susceptibility measurements reveal a D parameter of around $D = -0.23\,\mathrm{K}$. By variation of the counter ions and solvent molecules, the molecular C_3 symmetry can be slightly changed. This results in a tuning of the transversal anisotropy parameter that can be directly observed in low temperature single crystal Hall probe measurements: No tunneling steps were present in these measurements. Based on ac and dc relaxation measurements we show, that the transversal anisotropy is completely quenched in some cases. For the first time it is proved that a true C_3 molecular symmetry can lead to a vanishing E term and therefore to stable magnetized state over month without an external field.

1. Hoeke, V., K. Gieb, P. Muller, L. Ungur, L.F. Chibotaru, M. Heidemeier, E. Krickemeyer, A. Stammler, H. Bogge, C. Schroder, J. Schnack, T. Glaser, Chemical Science, **3**, 2868 (2012).

MA 41: Topological Insulators 4 (jointly with DS, HL, MA, and O)

Time: Thursday 15:00–18:00 Location: H18

Topical Talk MA 41.1 Thu 15:00 H18

Correlation Effects in Quantum Spin Hall Insulators — •Martin Hohenadler — Theoretische Physik I, Universität Würzburg, 97074 Würzburg, Germany

Time-reversal invariant insulating states with topological properties, including topological insulators, have been in the focus of research in recent years. On the theoretical side, electronic correlation effects are of particular interest, as they can both destroy and create topological phases. This talk gives an overview of research on two-dimensional, correlated topological insulators, with a focus on quantum Monte Carlo results for the Kane-Mele-Hubbard model.

MA 41.2 Thu 15:30 H18

All in-ultra-high-vacuum study of thin film topological insulators: Bi_2Te_3 — •Katharina Hoefer, Diana Rata, Christoph Becker, and Liu Hao Tjeng — Max Planck Institute for Chemical Physics of Solids

Thin films of topological insulators offer the possibility for the experimental study of the expected spectacular phenomena occurring at the surface of or interface with these materials due to the increased surface to bulk ratio in comparison to bulk crystals. Bulk materials are always defective which leads to extra contributions in conductance.

High quality thin films of Bi_2Te_3 were grown on α-Al_2O_3(0001) and BaF_2(111) using Molecular Beam Epitaxy. A two-step growth procedure provides high quality epitaxial films despite the large lattice mismatch of 9% to Al_2O_3; the mismatch to BaF_2 is less than 1%.

To protect the surface integrity an all in-ultra-high-vacuum study is crucial. This means not only the preparation and characterization by RHEED, LEED, XPS and ARPES, but especially the transport measurements are performed in-ultra-high-vacuum. The results of this study and ongoing work will be presented.

MA 41.3 Thu 15:45 H18

Magnetotransport in MBE-grown topological insulator $(Bi_{1-x}Sb_x)_2Te_3$ thin films — •Christian Weyrich[1], Tobias Merzenich[1], Igor E. Batov[1,2], Gregor Mussler[1], Jörn Kampmeier[1], Yulieth Arango[1], Detlev Grützmacher[1], and Thomas Schäpers[1,3] — [1]Peter Grünberg Institute (PGI-9), Research Centre Jülich GmbH, 52425 Jülich, Germany — [2]Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka, 142432, Moscow Distr., Russia — [3]II. Physikalisches Institut, RWTH Aachen University, 52056 Aachen, Germany

We report on the magnetotransport study of topological insulator $(Bi_{1-x}Sb_x)_2Te_3$ thin films. The films were grown on a silicon on insulator (SOI) substrate with a Si(111)-layer on top by molecular beam epitaxy. In Bi_2Te_3 samples, we observed a positive magnetoresistance at low magnetic fields with a cusplike minimum at $B = 0$ (weak antilocalization) as well as positive magnetoresistance in the entire magnetic field range (up to 12 T). The weak antilocalization effect disappears when an in-plane field is applied, showing the anisotropy between the transport parallel and perpendicular to the quintuple-layers. The estimated phase coherent lengths up to 250 nm at low temperatures are comparable to those previously obtained for Bi_2Te_3. The magnetotransport measurements were also performed on MBE-grown films of Sb_2Te_3 (p-doped) as well as on the ternary compound $(Bi_{1-x}Sb_x)_2Te_3$ ($0<x<1$). A transition from n- to p-doping depending on x has been seen in the measurements.

MA 41.4 Thu 16:00 H18

Surface state contribution to thermoelectric transport in Bi_2Te_3 — •Nicki F. Hinsche[1], Florian Rittweger[1], Peter Zahn[3] und Ingrid Mertig[1,2] — [1]Martin-Luther-Universität, Institut für Physik, Von-Seckendorff-Platz 1, DE-06120 Halle — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, DE-06120 Halle — [3]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 51 01 19, DE-01314 Dresden

Bulk Bi_2Te_3 and related heterostructures are well known as efficient thermoelectric materials [1,2]. Recent research revealed Bi_2Te_3 to be a strong topological insulator, i.e. its bulk is insulating, while its surface is metallic due to the presence of robust gapless surface states [3]. While the spin structure and the low-temperature electrical transport gained much attention, the physics of the thermoelectric transport is still under debate. To contribute on this, we studied the electronic structure of the Bi_2Te_3 surface with a fully relativistic screened Korringa-Kohn-Rostoker Green's function method. The thermoelectric transport properties were calculated within the relaxation time approximation of the Boltzmann theory. The influence of temperature and doping on the thermoelectric properties of the surface state were analysed in detail.

[1] T. M. Tritt *et al.*, MRS bulletin **31**, 188 (2006)
[2] N. F. Hinsche *et al.*, Phys. Rev. B **86**, 085323 (2012)
[3] H. Zhang *et al.*, Nature Phys. **5**, 438 (2009)

MA 41.5 Thu 16:15 H18

Quasi-ballistic transport of Dirac fermions in a Bi_2Se_3 nanowire — •Joseph Dufouleur — IFW-Dresden, Dresden, Germany

Quantum coherent transport of Dirac fermions in a mesoscopic

nanowire of the 3D topological insulator Bi_2Se_3 is studied in the weak-disorder limit. At very low temperatures, many harmonics are evidenced in the Fourier transform of Aharonov-Bohm oscillations, revealing the long phase coherence length of surface states. Remarkably, from their exponential temperature dependence, we infer an unusual 1/T power law for the phase coherence length. This decoherence is typical for quasi-ballistic fermions weakly coupled to the dynamics of their environment.

15 min. break

MA 41.6 Thu 16:45 H18

Quasi-ballistic transport of Dirac fermions in a Bi_2Se_3 nanowire — •Joseph Dufouleur[1], Louis Veyrat[1], Andreas Teichgräber[1], Stephan Neuhaus[1], Christian Nowka[1], Silke Hampel[1], J érôme Cayssol[2,3], Joachim Schumann[1], Barbara Eichler[1], Oliver Schmidt[1], Bernd Büchner[1], and Romain Giraud[1,4] — [1]Leibniz Institute for Solid State and Materials Research, IFW Dresden, 01171 Dresden, Germany — [2]LOMA, University Bordeaux 1, F-33045 Talence, France — [3]Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [4]CNRS - Laboratoire de Photonique et de Nanostructures, Route de Nozay, 91460 Marcoussis, France

Quantum coherent transport of Dirac fermions in a mesoscopic nanowire of the 3D topological insulator Bi_2Se_3 is studied in the weak-disorder limit. At very low temperatures, many harmonics are evidenced in the Fourier transform of Aharonov-Bohm oscillations, revealing the long phase-coherence length of surface states. Remarkably, from their exponential temperature dependence, we infer an unusual $1/T$ power law for the phase coherence length $L_\varphi(T)$. This decoherence is typical for quasi-ballistic fermions weakly coupled to the dynamics of their environment.

MA 41.7 Thu 17:00 H18

Magnetotransport in disordered HgTe ribbons — •Sven Essert and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

HgTe quantum wells allow the realization of 2D topological insulator structures. They feature edge states which are protected from backscattering by time-reversal symmetry leading to dissipationless transport in the presence of non-magnetic disorder. We perform transport calculations using the four-band BHZ model to investigate the lifting of this protection by an external magnetic field. We find that the edge state transport is very robust to the application of a perpendicular magnetic field as long as the transport is still in the quasi-one dimensional regime, i.e. as long as the system is far from a topological phase transition to the topologically trivial insulating phase. However, by gating parts of the system to the metallic regime and thereby allowing for true 2d transport, the effect of the magnetic field can be drastically increased.

MA 41.8 Thu 17:15 H18

Probing the Band Topology of Mercury Telluride through Weak Localization and Antilocalization — •Viktor Krueckl and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg

We investigate the effect of weak localization (WL) and weak antilocalization (WAL) in the diffusive transport through HgTe/CdTe quantum wells. Our results reveal different transitions between WL and WAL depending on the Fermi energy as well as the band topology [1]. If spin-orbit interactions from bulk and structure inversion asymmetry can be neglected, the magnetoconductance of a system with inverted band ordering features a transition from WL to WAL and back. This is a signature of the Berry phase arising for inverted band ordering and not present in heterostructures with conventional ordering. In presence of strong spin-orbit interaction both band topologies exhibit WAL, which is distinctly energy dependent solely for quantum wells with inverted band ordering. This can be explained by an energy-dependent decomposition of the Hamiltonian into two blocks.

[1] V. Krueckl and K. Richter, Semicond. Sci. Technol. **27**, 124006 (2012)

MA 41.9 Thu 17:30 H18

Robustness of edge states in non-centrosymmetric superconductors — •Raquel Queiroz und Andreas P. Schnyder — Max Planck Institut für Festörperforschung, 70569 Stuttgart, Germany

Nodal superconductors without inversion symmetry have non-trivial topological properties, manifested by topologically protected flat-band edge states [1-3]. Since the bulk is not fully gapped, the edge states of nodal superconductors can in principle be susceptible to impurities, which break translational symmetries. Using recursive Green's function techniques we study the robustness of these edge states against both magnetic and non-magnetic disorder. We show that for weak and dilute non-magnetic impurities, a finite number of mid-gap edge states remains at zero-energy. We compute the zero bias conductance of a junction between a normal lead and a non-centrosymmetric superconductor as a function of disorder strength. It is found that the flat-band edge states give rise to a nearly quantized zero-bias conductance even in the presence of non-magnetic impurities.

[1] A. P. Schnyder and S. Ryu, Phys. Rev. B 84, 060504(R) (2011)
[2] P. M. R. Brydon, A. P. Schnyder, and C. Timm, Phys. Rev. B 84, 020501(R) (2011)
[3] A. P. Schnyder, P. M. R. Brydon, and C. Timm, Phys. Rev. B 85, 024522 (2012)

MA 41.10 Thu 17:45 H18

The Kondo cloud in helical edge states — •Thore Posske and Björn Trauzettel — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

The Kondo cloud is one of the last left unobserved phenomena of the Kondo effect. It stands for spatially extended spin-spin correlation between the electrons in the leads and the spin of the impurity in a Kondo system. Attempts to measure the Kondo cloud directly at the impurity usually perturb the system vastly and therefore modify the Kondo cloud. Helical edge states of topological insulators obey a unique coupling of the direction of motion and the spin degree of freedom. This, as we show, allows for the possibility to find signatures of the Kondo cloud far away from its origin by measuring current-current correlations.

MA 42: Focus Session: Dynamical Mean-Field Approach to Correlated Electron Materials (jointly with MA)

During the last few years conventional band-structure calculations in the local density approximation (LDA) have been merged with a modern many-body approach, the dynamical mean-field theory (DMFT), into a novel computational method referred to as LDA+DMFT. This framework has proved to be a breakthrough for the realistic modeling of the electronic, magnetic, and structural properties of correlated electron materials. The Focused Session will review the significant recent progress made in this internationally active field of research.

Organizers: Ralph Claessen (University of Würzburg), Eva Pavarini (Forschungszentrum Jülich), Dieter Vollhardt (University of Augsburg)

Time: Thursday 15:00–17:45 Location: H20

Invited Talk MA 42.1 Thu 15:00 H20

How Bad Metals Turn Good: Spectroscopic Signatures of Resilient Quasiparticles — •Antoine Georges — College de France and Ecole Polytechnique, France

Many materials with strong electronic correlations display metallic-like resistivity up to very high temperature, with values exceeding the Ioffe-Regel-Mott (IRM) criterion. Yet, at low enough temperature, good metallic conductivity obeying Fermi liquid behaviour can be recovered. In this talk, I will explore how this crossover takes place. I will show that the Fermi liquid scale, which is strongly suppressed by strong correlations, should not be confused with the much higher Brinkman-Rice scale, at which incoherent transport sets in.

In between these two scales, an extended regime of metallic transport applies, in which the resistivity is smaller than the IRM value but does not follow a T^2 Fermi-liquid law. Well-defined quasiparticle excitations do exist in this regime, as manifested in the one-particle spectral function and optical conductivity, with properties distinct from Landau and Drude theories. For a hole-doped Mott insulator, a strong particle-hole asymmetry applies down to low-energy: electron-like excitations are much longer lived, placing these quasiparticle excitations on the 'dark side' for ARPES spectroscopy. This also has implications for the temperature dependence of the thermopower.

[1] X. Deng, J. Mravlje, R. Zitko, M. Ferrero, G. Kotliar, A. Georges, arXiv:1210.1769

Topical Talk MA 42.2 Thu 15:30 H20

Correlation Effects in Organic Superconductors — •Roser Valenti — Institut für Theoretische Physik, Goethe Universität Frankfurt, Frankfurt, Germany

Organic charge transfer salts are unique correlated systems with a complex phase diagram that can be finely tuned by chemical substitution or moderate pressures. Observed phases in these systems include metals, Fermi liquids, Mott insulators, antiferromagnets, spin liquids, and unconventional superconductors. A realistic description of these systems can be provided by a combination of density functional theory with dynamical mean field theory (LDA+DMFT). Such an approach has not been attempted in the past due to the complex crystal structures of these materials. Here we present recent LDA+DMFT calculations based on a new scheme to obtain molecular Wannier orbitals for a few families of organic layered conductors and discuss their spectral and optical conductivity properties.

[1] H. C. Kandpal, I. Opahle, Y.-Z. Zhang, H. O. Jeschke, and R. Valenti, Phys. Rev. Lett. **103**, 067004 (2009)
[2] J. Ferber, K. Foyevtsova, H.O. Jeschke, and R. Valenti, arXiv:1209.4466 (2012)

Topical Talk MA 42.3 Thu 16:00 H20

Photoemission Study of Correlated Oxides at High Temperatures — Jonas Weinen[1], Stefano Agrestini[1], Martin Rotter[1], Alexander Komarek[1], Yen-Fa Liao[2], Ku-Ding Tsuei[2], Chien-Te Chen[2], and •Hao Tjeng[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]National Synchrotron Radiation Research Center, Hsinchu, Taiwan

Strongly correlated oxides show often quite spectacular and intriguing properties which can be traced back to the presence of several competing interactions leading to various forms of ordered phases at low temperatures. In order to unravel which of the interactions are relevant, we have set out to study the excitation spectra of the several benchmark oxides as a function of temperature. By carrying out bulk-sensitive hard-x-ray photoemission experiments at high temperatures, we can follow the changes in the spectra and thereby determine which and how local spin and orbital degrees of freedom as well as nearest neighbour spin-spin correlations influence the intricate and complex electronic structure of correlated oxides.

15 min. break

Invited Talk MA 42.4 Thu 16:45 H20

Dynamical Mean Field Theory of Collective Excitations — •Alexander Lichtenstein — University of Hamburg, Hamburg, Germany

Dynamical mean field theory (DMFT) in combination with the first-principle scheme is an optimal starting point to go beyond static density functional approximation and include effects of local spin, orbital and charge fluctuations. In order to investigate collective non-local excitations we formulate a general framework which start from the DMFT solution for strongly correlated materials within a numerically exact continuous-time Quantum Monte Carlo impurity solver[1] and use a dual-particle transformation in the path integral formalism to find an optimal diagrammatic series for the lattice Green functions.

[1] E. Gull, A.J. Millis, A.I. Lichtenstein, A.N. Rubtsov, M. Troyer, and Ph. Werner, Rev. Mod. Phys. **83**, 349 (2011)

Topical Talk MA 42.5 Thu 17:15 H20

Electronic Correlations beyond Dynamical Mean Field Theory — •Karsten Held — Institute for Solid State Physics, TU Wien

Dynamical mean field theory has been a big step forward for our understanding of electronic correlations. A major part of the electronic correlations, the local ones, are included. The arguably most fascinating physical phenomena of solid state physics, however, such as (quantum) criticality and the physics of high-T superconductors are based on non-local correlations.

To address these problems, recently diagrammatic extensions of the dynamical mean field theory have been developed, coined dynamical vertex approximation [1] and dual fermion approach [2]. Among others, these approaches allow for describing spin-fluctuation-mediated pseudogaps and for calculating critical exponents of the Hubbard model [3].

[1] A. Toschi, A. A. Katanin, and K. Held, Phys. Rev. B **75**, 045118 (2007)
[2] A. N. Rubtsov, M. I. Katsnelson, and A. I. Lichtenstein, Phys. Rev. B **77**, 033101 (2008)
[3] G. Rohringer, A. Toschi, A. Katanin, and K. Held, Phys. Rev. Lett. **107**, 256402 (2011)

MA 43: Magnetization Dynamics II of 3

Time: Thursday 15:00–17:45 Location: H22

MA 43.1 Thu 15:00 H22

Ultrafast spin transport as key to femtosecond demagnetization — •Andrea Eschenlohr[1], Marco Battiato[2], Pablo Maldonado[2], Niko Pontius[1], Torsten Kachel[1], Karsten Holldack[1], Rolf Mitzner[1], Alexander Föhlisch[1], Peter M. Oppeneer[2], and Christian Stamm[1] — [1]Institut für Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Str. 15, 12489 Berlin, Germany — [2]Department of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden

Ultrafast demagnetization of ferromagnetic metals is typically triggered by excitation with a femtosecond laser pulse. Here we demonstrate that hot electrons transported into a ferromagnetic layer can induce demagnetization as fast and efficient as direct laser excitation. We investigate a layered structure consisting of a Ni film covered by a Au layer, with the thickness of the Au layer chosen such that the incident laser pulse is completely absorbed. Magnetization dynamics in the buried Ni film is measured with x-ray magnetic circular dichroism in transmission geometry at the BESSY II Femtoslicing source, finding sub-picosecond demagnetization of equal magnitude as in a directly excited Ni film. Simulations show that the observed demagnetization is due to spin-dependent transport of non-equilibrium electrons from the Au layer through the ferromagnetic layer into the substrate.

MA 43.2 Thu 15:15 H22

Ultrafast Demagnetization in Ferromagnets: The Influence of Spin flip Scattering and Exchange Splitting Dynamics — •Benedikt Y. Mueller, Hans C. Schneider, and Bärbel Rethfeld — Technical University Kaiserslautern, Germany

The effect of the ultrafast demagnetization process after a femtosecond laser irradiation has been studied intensively for almost two decades [1,2,3] but a complete microscopic theory is still lacking. As a step towards this goal, we propose and analyze a dynamical Elliott-Yafet-type approach that takes into account the effects of spin-orbit interaction as well as the spin-diagonal scattering mechanisms within a microscopic description. Using the density of states of Nickel in our model [4,5]

and, additionally, a *dynamical* splitting between the majority and minority bands, we trace the transient non-equilibrium electron distributions providing an energy-resolved picture of ultrafast magnetization dynamics. We illustrate the importance of the interplay of equilibration of temperatures and chemical potentials between the electrons [6] as well as the changes in the Stoner exchange splitting.

[1] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250 (1996)
[2] J. Hohlfeld et al., Phys. Rev. Lett. 78, 25 (1997)
[3] B. Koopmans et al., Nature Materials 9, 3 (2010)
[4] B. Rethfeld et al., Phys. Rev. B 65, 214303 (2002)
[5] B. Y. Mueller et al., AIP Conf. Proc. 1461, 609 (2012)
[6] B. Y. Mueller et al., New Journal of Physics 13, 123010 (2011)

MA 43.3 Thu 15:30 H22

Spin-flip scattering versus superdiffusive transport in the femtosecond-demagnetization of Nickel — •Oliver Schmitt, Daniel Steil, Sabine Alebrand, Stefan Mathias, Mirko Cinchetti, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany

The phenomenon of ultrafast demagnetization is currently explained by at least two different theories: Spin-flip dynamics via the Elliott-Yafet (EY)-mechanism [1,2], and superdiffusive spin transport [3]. To disentangle the influence of these two spin relaxation mechanisms on the ultrafast demagnetization process, we have performed studies using the time-resolved magneto-optical Kerr effect (TRMOKE) on Ni samples for different film thicknesses and substrate materials. The obtained results demonstrate a strong thickness dependence of the maximum magnetization quenching as well as a dependence of the demagnetization constant on the substrate material. The applicability of EY and superdiffusive transport is discussed on the basis of the obtained results.

[1] B. Koopmans, G. Malinowski, F. Dalla Longa, D. Steiauf, M. Fähnle, T. Roth, M. Cinchetti and M. Aeschlimann, NMat **9**(3): 259-265 **(2010)**

[2] T. Roth, A. J. Schellekens, S. Alebrand, O. Schmitt, D. Steil, B. Koopmans, M. Cinchetti, and M. Aeschlimann, PRX **2**, 021006 **(2012)**

[3] M. Battiato, K. Carva, and P. M. Oppeneer, PRB **86**, 024404 **(2012)**

MA 43.4 Thu 15:45 H22

Unified theory of ultrafast femtosecond and picosecond spin dynamics in the three-center magnetic cluster Ni_3Na_2 — •Georgios Lefkidis[1], Hongping Xiang[1,2], and Wolfgang Hübner[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Department of Physics and Astronomy, California State University, Northridge, USA

Using *ab initio* quantum chemistry, varying the interatomic distances, and including spin-orbit coupling and a static external magnetic field, we investigate the laser-induced, ultrafast magnetic switching in Ni_3Na_2 [1,2]. Our studies yield a very accurate bond-length sensor based on spin dynamics, as well as a unified picture of subpicosecond, laser-induced and picosecond, phonon-induced spin-flip processes.

Specifically we find that the geometric distortions lead to magnetic phases in the cluster, in which the strongly localized spins exhibit different orientations and hence respond differently to laser pulses. At the critical interatomic distances the spins undergo a sudden reorientation (spin-phonon scattering). This scattering is indirect and mediated through an energetically higher-lying electronic state.

Finally, to completely unify the laser-induced and the phonon-induced processes we calculate their longitudinal and transverse relaxation times and draw an analogy to classical precessional switching.

[1] H. P. Xiang, G. Lefkidis, and W. Hübner, Phys. Rev. B **86**, 134402 (2012)

[2] H. P. Xiang, G. Lefkidis, and W. Hübner, J. Supercond. Nov. Magn. (in press) (2012)

MA 43.5 Thu 16:00 H22

The lattice response of femtosecond laser excited Nickel investigated by time-resolved electron diffraction — •Carla Streubühr, Ping Zhou, Thorsten Brazda, Frank Meyer-zu Heringdorf, Michael Horn-von Hoegen, Dietrich von der Linde, and Uwe Bovensiepen — Universität Duisburg-Essen

In ultrafast magnetization dynamics of ferromagnets like Ni the lattice response to the femtosecond laser excitation is essential [1]. Here we report on an experimental study of the lattice dynamics driven by laser excitation in 20 nm thick Nickel single-crystalline films using time resolved transmission electron diffraction. The electron diffraction patterns of the freestanding Ni (001) films were recorded as function of delay time between optical pump ($h\nu$ = 1.5 eV) and electron probe (E_kin = 30 keV).

The integrated intensity of all diffraction spots decreased after the laser excitation. Our analysis indicates that the observed decrease does not scale with the scattering vector which is inconsistent with the Debye-Waller effect resulting from lattice heating. Furthermore, the diffraction intensity drop was proportional to the intensity of the laser pulse rather than the laser fluence. Both observations indicate a higher order lattice excitation by the laser and argue against the excitation by electron-phonon scattering. Possible alternative excitation mechanisms will be discussed.

[1] B. Koopmans et al, Nature Materials **9**, 259 (2010)

MA 43.6 Thu 16:15 H22

Theory of Thermal Magnetization Switching in Rare-Earth-based Ferrimagnets — •Sönke Wienholdt[1], Denise Hinzke[1], Karel Carva[2], Peter Oppeneer[3], and Ulrich Nowak[1] — [1]University of Konstanz, Germany — [2]Charles University in Prague, Czech Republic — [3]Uppsala University, Sweden

Recently it was demonstrated that a linearly polarized laser pulse is able to reverse the magnetization in ferrimagnetic GdFeCo on a purely thermal basis within a ps time scale [1,2]. Thermal opto-magnetic switching has so far only been obtained in rare-earth-based ferrimagnets like GdFeCo [1,2]. Hence it is assumed that the antiferromagnetic exchange interaction plays a role. Additionally the substanstially different demagnetization times of rare earths (RE) and transition metals (TM) [3,4] seems to be crucial [1,2]. Nevertheless the general mechanisms, especially the role of the highly non-equilibrium transient ferromagnetic-like state, are still up for debate. We developed an atomistic multi-band spin model for RE-based ferrimagnets, where we distinguish between d- and f-electrons in the RE [5]. Our numerical results show a transient ferromagnetic-like state of the right magnitude as well as the switching of the sublattices. We explain the origin of this by dissipationless dynamics occuring on a timescale below one ps.

[1] I. Radu et al., Nature 472, 205 (2011) [2] T.A. Ostler et al., Nat. Comm. 3, 666 (2012) [3] B. Koopmans et al., Nat. Mat. 9, 259 (2009) [4] M. Wietstruk et al., Phys Rev Lett. 106, 127401 (2011) [5] S. Wienholdt et al., submitted

MA 43.7 Thu 16:30 H22

Controlling the Competition between Optically Induced Ultrafast Spin-Flip Scattering and Spin Transport in Magnetic Multilayers — •S. Mathias[1], E. Turgut[2], C. La-o-vorakiat[2], J. M. Shaw[3], P. Grychtol[2], H. T. Nembach[3], D. Rudolf[4], R. Adam[4], M. Aeschlimann[1], C. M. Schneider[4], T. J. Silva[3], M. M. Murnane[2], and H. C. Kapteyn[2] — [1]TU Kaiserslautern and Research Center OPTIMAS, 67663 Kaiserslautern, GER — [2]JILA, University of Colorado, Boulder, USA — [3]NIST, Boulder, USA — [4]Peter Grünberg Institut, Research Centre Jülich, 52425, Jülich, GER

The study of ultrafast dynamics in magnetic materials provides rich opportunities for greater fundamental understanding of correlated phenomena in solid-state matter, because many of the basic microscopic mechanisms involved are as-yet unclear and are still being uncovered. Recently, two different possible mechanisms have been proposed to explain ultrafast laser induced magnetization dynamics: spin-flip scattering and superdiffusive spin transport. In this work, we use multilayers of Fe and Ni with different metals and insulators as the spacer material to conclusively show that both optically induced demagnetization, due to spin scattering processes, and spin-currents contribute simultaneously to ultrafast dynamics in magnetic materials. Moreover, we can control the competition between these two processes, and in some cases completely suppress interlayer spin currents as a sample undergoes rapid demagnetization. Finally, by reversing the order of the Fe/Ni layers, we experimentally show that spin-currents are directional in our samples, predominantly flowing from the top to the bottom layer.

MA 43.8 Thu 16:45 H22

Spin-lattice dynamics under conservation of angular momentum — •Matthias Assmann and Ulrich Nowak — University Konstanz, 78457 Konstanz, Germany

On ultrafast time scales conservation laws can enforce strong constraints onto the magnetization dynamics. These restrictions cannot be described by the Landau-Lifshitz-Gilbert equation with its dissipative dynamics. In this talk a set of coupled microscopic equations of

motion for the spin and lattice dynamics is proposed, which include a direct coupling between spins and lattice, so that energy and angular momentum can be transferred between these subsystems. For the coupling between lattice and spin degrees of freedom a two-site anisotropy arising from spin-orbit coupling is considered as well as magnetic dipole-dipole interaction. Both of these coupling terms allow for a dynamics, which obey all conservation laws, including the conservation of total angular momentum. For the numerical treatment in our simulations new sympletic algorithms are used. As a test the Einstein-De Haas effect is reproduced as well as the Barnett effect. Furthermore, heat dissipation from the magnetic subsystem into the lattice is investigated in film geometries.

MA 43.9 Thu 17:00 H22

Temperature Dependence of Nutation in Magnetic Nanostructures — •Danny Böttcher[1,2] and Jürgen Henk[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

The dynamics of magnetic moments in nanostructures is closely linked to that of gyroscopes. The Landau-Lifshitz-Gilbert equation describes precession and relaxation but does not include nutation. Both precession and relaxation have been observed in experiments, in contrast to nutation. We have extended the atomistic Landau-Lifshitz-Gilbert equation as well as the Landau-Lifshitz-Miyazaki-Seki equation, that specifies the temperature in strong time correlated systems, by a nutation term. This allows us to study the significance of nutation in magnetization dynamics of nanostructures: for a single magnetic moment, a chain of Fe atoms, Co islands on Cu(111) as well as finite temperature. We find that nutation is significant at low-coordination sites and on the timescale of about 100 fs in systems with low time correlation at finite temperatures; its observation challenges todays experimental techniques.

MA 43.10 Thu 17:15 H22

Statistical moment equations for stochastic spin dynamics in phase space: a uniaxial paramagnet subjected to a dc bias field of arbitrary orientation — •William Coffey[1], Yuri Kalmykov[2], and Sergey Titov[3] — [1]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [2]LAMP, University of Perpignan Via Domitia, 52, Ave. Paul Alduy, 66860 Perpignan, France — [3]Kotelnikov Institute of Radio Engineering and Electronics RAS, Vvedenskii Sq. 1, Fryazino, Moscow reg., 141190, Russian Federation

Spin dynamics in a dissipative environment are treated via the evolution (master) equation for spin orientations in the phase space in the weak spin-bath coupling and high temperature limits. The explicit solution is written for an arbitrary spin Hamiltonian as a finite series of spherical harmonics analogous to the (infinite) Fourier series representation of the classical case governed by the Fokker-Planck equation. Therefore, the expansion coefficients, i.e., the statistical averages of the spherical harmonics may be determined from a differential-recurrence relation yielding the stochastic spin dynamics for arbitrary spin number S. For large S the differential-recurrence relations reduce to those generated by the Fokker-Planck equation. Thus the spin dynamics may be treated in a manner transparently linking to the classical representations, providing quantum corrections to classical averages. The method is illustrated via the magnetization relaxation of a uniaxial paramagnet with a dc field applied at an arbitrary angle to the easy axis.

MA 43.11 Thu 17:30 H22

Phonon mediated Bose-Einstein magnon condensation — •Peter Clausen[1], Dmytro A. Bozhko[1,2], Andrii V. Chumak[1], Alexander A. Serga[1], Gennadii A. Melkov[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Germany — [2]Faculty of Radiophysics, Taras Shevchenko National University of Kyiv, Ukraine

We report on the first observation of a magneto-elastic magnon (MEM) mode populated due to the thermalization of a parametrically driven magnon gas. The gas behavior is investigated by time- and wavevector-resolved Brillouin light scattering (BLS) spectroscopy in an yttrium iron garnet (YIG) film. Two peaks of the magnon density with very similar energies but different wavevectors are observed near the bottom of the magnon spectrum. The magnons with the lower wavevector are identified as a Bose-Einstein magnon condensate (BEC) and the others with an approximately two-times larger wavevector as the MEM mode.

Our investigations show that the MEM mode starts to be visible at pumping powers at least ten times smaller than the threshold of the BEC formation. Furthermore, in contrast to the BEC peak, the width of the MEM mode peak is practically independent from the magnon density. The population characteristic of the MEM mode can be understood as a result of a phonon induced coupling of high magnon modes, and thus the formation of an effective transfer channel of the thermalized magnons to the bottom of the spin-wave spectrum.

Support by the DFG within the SFB/TRR 49 is gratefully acknowledged.

MA 44: Surface Magnetism (jointly with O)

Time: Thursday 15:00–18:45 Location: H3

Invited Talk MA 44.1 Thu 15:00 H3

Spin-polarized scanning field emission microscopy and spectroscopy — •Anika Schlenhoff — Institute of Applied Physics, University of Hamburg

High electric fields can discharge electrons from a solid, thereby generating an emission current, which becomes spin-polarized when using a magnetic emitter. A very local injection of these electrons is achieved when approaching a magnetic tip to a sample in an SP-STM setup, and scanning allows for magnetic imaging by means of spin-polarized emission conductivity measurements. Although field emission is routinely used for microscopy purposes, the question remained open how it affects magnetism on the local scale. A detailed understanding of the interplay of hot-electron spins with magnets is essential for the interpretation of many hot electron spin phenomena and characterization techniques, as well as for applications in spintronic devices.

Here we show that a spin-polarized field-emission current resonantly injected into magnets, consisting of only about 50 iron atoms on a W(110) surface, generates considerable Joule heating and spin-transfer torque, thereby severely affecting the thermally driven magnetization reversal. The switching frequency is increased due to phonon generation, and a lifetime asymmetry develops with increasing emission current, most likely driven by Stoner excitations. Even magnetization reversal of quasistable nanomagnets can be triggered by spin-polarized field-emission. Our experiments demonstrate the capability of spin-polarized scanning field emission microscopy for magnetic observation and controlled manipulation on the atomic scale at nm distances.

MA 44.2 Thu 15:30 H3

Large wave vector surface spin waves of the nanomartensitic phase in ultrathin iron films on Cu(100) and fcc Co(100) — •Rajeswari Jayaraman, Harald Ibach, and Claus M. Schneider — Peter Grünberg Insitut, Forschungszentrum Jülich, 52425 Jülich, Germany

It is generally accepted that thin-film magnetism is strongly affected by even small structural modifications. Much less is known about the influence of structure on magnetic excitations, in particular, spin waves. Using electron energy loss spectroscopy we have studied the dispersion of large wave vector surface spin waves of a system for which details of the structure became known only recently, namely ultrathin iron films grown on Cu(100) surfaces. We find the spin wave dispersion to be nearly identical to the dispersion reported for bcc Fe(110) layers grown on W(110). We therefore conclude that the spin wave signal stems from the "nanomartensitic" phase of Fe/Cu(100) and that this phase is not merely a surface phase but encompasses the deeper layers. The same spin wave dispersion and LEED pattern as for the Fe/Cu(100) system is observed when Fe is deposited on fcc Co(100)/Cu(100). We therefore conclude that these Fe films likewise assume the nanomartensite structure.

MA 44.3 Thu 15:45 H3

Parity effect in ground state localization of antiferromag-

netic chains coupled to a ferromagnet — Simon Holzberger[1], Tobias Schuh[1], Samir Lounis[2], Stefan Blügel[2], and •Wulf Wulfhekel[1] — [1]Physikalisches Institut, KIT — [2]Peter Grünberg Institut, Forschungszentrum Jülich

We investigate the ground states of antiferromagnetic Mn nanochains on Ni(110) by spin-polarized scanning tunneling microscopy in combination with theory. While the ferrimagnetic linear trimer experimentally shows the predicted collinear classical ground state, no magnetic contrast was observed for dimers and tetramers where non-collinear structures were expected based on ab-initio theory. This striking observation can be explained by zero-point energy motion for even numbered chains derived within a classical equation of motion leading to non classical ground states. Thus, depending on the parity of the chain length, the system shows a classical or a quantum behavior.

MA 44.4 Thu 16:00 H3

Constant current contrast in spin-polarized STM — •Krisztian Palotas — Budapest University of Technology and Economics, Department of Theoretical Physics, Budapest, Hungary

This work is concerned with the theoretical description of the contrast, i.e., the apparent height difference between two lateral surface positions on constant current spin-polarized scanning tunneling microscopy (SP-STM) images.

We propose a method [1] to predict the bias voltage dependent magnetic contrast from single point tunneling current or differential conductance measurements, without the need of scanning large areas of the surface. Depending on the number of single point measurements, the bias positions of magnetic contrast reversals and of the maximally achievable magnetic contrast can be determined. We validate this proposal by simulating SP-STM images on a complex magnetic surface employing a recently developed approach based on atomic superposition [2]. Furthermore, we show evidence that the tip electronic structure and magnetic orientation have a major effect on the magnetic contrast. Our theoretical prediction should inspire experimentalists to considerably reduce measurement efforts for determining the bias dependent magnetic contrast on magnetic surfaces.

This research was supported by the OTKA PD83353, K77771, TAMOP-4.2.2.B-10/1-2010-0009 projects, and a Bolyai Grant.

[1] K. Palotas, arXiv:1207.3995 (2012).

[2] K. Palotas et al., Phys. Rev. B 83, 214410 (2011); Phys. Rev. B 84, 174428 (2011); Phys. Rev. B 85, 205427 (2012).

MA 44.5 Thu 16:15 H3

Mapping the energy landscape of the magnetoelectric phase transition in Fe nanoislands — •Lukas Gerhard[1], Rien Wesselink[1,2], Arthur Ernst[3], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [2]Faculty of Science and Technology and MESA+ Institute for Nanotechnology, University of Twente, 7500AE Enschede, The Netherlands — [3]Max-Planck-Institut fuer Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

Magnetoelectric coupling (MEC) offers the possibility to control the magnetic state of a material by applying an electric field raising the prospect of new applications in magnetic storage devices. Using the electric field of a scanning tunneling microscope (STM) tip we recently demonstrated strong MEC in metallic nano islands [1]. High electric fields of the order of 1 GV/m trigger a crystallographic and magnetic phase transition from antiferromagnetic fcc to ferromagnetic bcc in bilayer Fe islands on a Cu(111) surface. An extensive statistical analysis of the thermally activated switching at subcritical electric fields unveils the characteristic energies of the balance between the two states. We map this energy landscape as function of strain and electric field which gives us a thorough understanding of the critical parameters necessary to fine-tune the dynamics of MEC induced phase transitions. [1] L. Gerhard et al. Magnetoelectric coupling at metal surfaces. Nat. Nano 5, 792-797 (2010)

MA 44.6 Thu 16:30 H3

Role of magnetism in Catalysis: RuO2 (110) surface — •Engin Torun[1], Changming Fang[1,3], Gilles A de Wijs[1], and Robert de Groot[1,2] — [1]Electronic Structure of Materials, Radboud University Nijmegen, Institute for Molecules and Materials, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands — [2]Laboratory of Chemical Physics, Zernike Institute of Advanced Materials, Nijenborgh 4, NL-9747 AG Groningen, The Netherlands — [3]University of Vienna, Faculty of Physics, Computational Materials Physics, Sensengasse 8/12, 1090 Wien, Austria

The three conservation laws (energy, momentum and angular momentum) are well known, but the consequences of the last one are too often neglected. A clear example in electrochemistry is the electrolysis of water. Hydrogen production by electrolysis of water seemingly violates conservation of angular momentum because only one magnetic species is involved (oxygen). The losses in electrolysis are overwhelmingly dominated by the production of oxygen. While the ground state of oxygen is magnetic its first and second excited states are non-magnetic singlet states. This explains the losses at the anode. The oxygen is initially produced in a non-magnetic excited state. A fundamental solution of this problem is only possible by the introduction of a second magnetic species. We report calculations on the surface electronic structure of one of the best anodes, the RuO2 (110) surface. This surface itself is magnetic and a mechanism will be proposed how this second magnetic species allows the production of oxygen in its magnetic ground state. A similar situation in biology will be discussed.

MA 44.7 Thu 16:45 H3

Scanning tunneling spectroscopy of quantum well states in thin Pd(001) films — •Sujit Manna[1], Marek Przybylski[1,2], and Jürgen Kirschner[1,3] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [3]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

Scanning Tunneling Spectroscopy (STS) on transition metals with filled d-bands below Fermi level is hardly expected to yield features due to the d-states because their contribution to the tunneling current is much smaller than that of the sp-band states. We have investigated the electronic structure of thin Pd films grown on Cu(001) by STS at T=4.7K with single layer thickness resolution. We have identified the occupied d-band quantum well states (QWS), which arise from the electron confinement along the growth axis of Pd films and give rise to sharp peaks in the tunneling spectra. A quantitative analysis of the spectra yields the band dispersion, which is similar to the calculated free electron dispersion in bulk Pd along the Γ-L direction. Also the correlation between the QWS formed in the Pd films with magnetic anisotropy (MA) of adjacent Co films in the Co/Pd bilayer system will be shown and discussed. The step induced uniaxial MA is found to oscillate as a function of Pd film thickness with a period of 6 ML, in agreement with theoretical calculations [1]. [1] M. Cinal, J. Phys.: Condens. Matter 13, 901 (2001).

15 min. break

MA 44.8 Thu 17:15 H3

Spin-dependent Smoluchowski effect — •Marco Corbetta[1], Oleg Polyakov[1,2], Oleg Stepanyuk[1,2], Hirofumi Oka[1], Aleksander Saletsky[2], Dirk Sander[1], Valeriy Stepanyuk[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle (Saale), Germany — [2]Faculty of Physics, Moscow State University, Moscow, Russia

The Smoluchowski effect [1] focuses on the total electron charge density and it neglects that electrons carry a spin. In spin-polarized materials, it is not clear how majority and minority states contribute to the spin-dependence of this effect. To elucidate this point we perform spin-polarized scanning tunneling microscopy at the step edge of a bilayer high Co island on Cu(111) at 8 K. We measure maps of the differential conductance (dI/dV) for states of parallel (P) and anti-parallel (AP) orientation between tip and sample magnetization. From these maps we extract the asymmetry A of the differential conductance A=(dI/dVAP-dI/dVP)/(dI/dVAP+dI/dVP). This quantity is proportional to the spin polarization of the sample. We reveal striking spatial variations of the spin-polarization at the transition between the Co step and the Cu substrate with sub-nm spatial resolution and investigate its energy dependence. We find a variation of the tunnel magneto resistance ratio of more than 20% on a length scale of few Angstroms. We discuss our results on the basis of ab-initio calculations, spin-dependent electron charge flow supports our findings [2]. [1] R. Smoluchowski, Phys. Rev. 60, 661 (1941). [2] O. P. Polyakov et al., Phys. Rev. B, accepted (2012).

MA 44.9 Thu 17:30 H3

Temperature-dependent magnetic hysteresis of the differential conductance in spin-polarized scanning tunneling spectroscopy with Fe-coated W tips — •Soo-hyon Phark[1], Jeison 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 performed spin-polarized scanning tunneling spectroscopy on bilayer high Co islands of the nm size range [1] on Cu(111) for temperatures between 10 and 30 K in magnetic fields oriented normal to the sample surface. We use a W tip, heated to 2200 K in UHV, coated with 40-monolayer Fe. Increasing the temperature from 10 to 30 K, we observe a decline of the switching field of an individual Co island, and a reduced slope of the differential conductance around zero field [2]. The Néel-Brown model for the magnetic reversal process of the Co islands and a superparamagnetic response of the tip magnetization as described by the Langevin function gives a favorable description of the data. We estimate that the tip apex is composed of roughly 200 Fe atoms. This suggests that a Fe cluster, rather than a Fe film, determines that magnetic response of the tip. The role of the magnetic stray field of the Co island for the magnetic response of the tip is discussed.

[1] Ouazi, Wedekind, Rodary, Oka, Sander, Kirschner, Phys. Rev. Lett. 108, 107206 (2012). [2] Rodary, Wedekind, Sander, Kirschner, Jap. J. Appl. Phys. 47, 9013 (2008).

MA 44.10 Thu 17:45 H3

Magnetic coupling of single Co adatoms through Pd spacer layers — •Liudmila Dzemiantsova, Mahboubeh Hortamani, Christian Hanneken, André Kubetzka, Kirsten von Bergmann, and Roland Wiesendanger — Institut für Angewandte Physik, Universität Hamburg, Germany

The knowledge about the magnetic coupling on the atomic scale is crucial for the tailoring magnetic devices in reduced dimensions and the tuning their properties [1]. In particular, the dependence of the exchange coupling of magnetic adatoms on the thickness of the spacer layer is important for the fundamental understanding of magnetism and practical applications in spin-based technology [2].

We performed a combined experimental and theoretical investigation of Co atoms on top of a Pd spacer on Co/Ir(111). Using spin-polarized STM, spin contrast is achieved on Pd mono (ML)- and double-layer (DL) and on Co adatoms, which means that the electron density above the surfaces and adatoms is spin-polarized. In accordance with our experimental observations of Co atoms on the Pd spacer, our *ab initio* calculations show that Co layers adsorbed on top of a Pd mono- and double-layer are ferromagnetically coupled to the Co/Ir(111) underneath. The size of the magnetic coupling is reduced by a factor of three from a ML to a DL Pd spacer between the Co layers [3].

[1] F. Meier *et al.*, Science, 320, 82 (2008).
[2] A. A. Khajetoorians *et al.*, Science, 332, 1062 (2011).
[3] L. V. Dzemiantsova *et al.*, Phys. Rev. B, 86, 094427 (2012).

MA 44.11 Thu 18:00 H3

Complex Magnetism in Fe nanoclusters on Ir(111) — •David Bauer, Phivos Mavropoulos, Rudolf Zeller, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich

Recently, a square lattice of skyrmions of nanoscale dimension has been experimentally identified by spin-polarized scanning tunneling microscopy combined with first-principles calculations [1] as the magnetic ground state of an hexagonal Fe monolayer on the Ir(111) substrate. The magnetic structure is a result of a fine balance between the Heisenberg and biquadratic exchange, the four-spin interaction, magnetic anisotropy and the Dzyaloshinskii-Moriya interaction. This raises the question whether a single skyrmion is already encoded in a minimal hexagonal cluster of 7 atoms or *e.g.* in the next larger one of 19 atoms. To shed light onto this problem we apply our recently developed all-electron full-potential relativistic Korringa-Kohn-Rostoker Green-function method jointly with a model spin-dynamics code to study the non-collinear magnetism in finite nano-structures and clusters perfectly embedded in bulk materials or on surfaces.We find that the finite size of these clusters changes the balance between the magnetic interactions significa ntly. For example, also for the 19 atom cluster a strong non-collinear formation of spins was found, but qualitatively different to the skyrmion in the sense that most spins relax to an almost rectangular alignment with respect to their neighbors indicating that the Dzyaloshinskii-Moriya interaction determines the magnetic structure.

[1] S. Heinze et al. Nature Phys. **7**, 713 (2011).

MA 44.12 Thu 18:15 H3

Nano-skyrmions lattices and magnetic phase diagram of Fe/Ir(111) — •Nikolai Kiselev, David Bauer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Recently, a square lattice of skyrmions of nanoscale dimension has been experimentally identified by spin-polarized scanning tunneling microscopy combined with first-principle calculations [1] as the ground state of an hexagonal Fe monolayer on the Ir(111) substrate. Here, we present a detailed theoretical description of the magnetic phase diagram of Fe/Ir(111) obtained from Monte Carlo simulations in extended Heisenberg model employing parameters obtained from first-principles calculations. We give a comprehensive analysis of the ground state and field/temperature induced transitions and compare our results with experiment. We predict the existence of a new modulated state: an hexagonal lattice of skyrmions stabilized at high field and temperature. The transition between hexagonal and square skyrmion lattices is characterized by an extremely strong hysteretic effect and the abrupt change of the topological number. We discuss in details general aspects of the nano-skyrmions, in particular leading terms in the Hamiltonian, which are responsible for the stability of skyrmions in low dimensional magnetic systems.

[1] S. Heinze et al. Nature Phys. 7, 713 (2011).

MA 44.13 Thu 18:30 H3

Ab initio study of ferromagnetic Co-chains on the (5x1) Iridium(001) surface — •Bertrand Dupe[1], Yuriy Mokrousov[2], and Stefan Heinze[1] — [1]Institut für Theoretische Physik und Astrophysik, CAU Kiel, Germany — [2]Peter Grünberg Institut and Institute for Advanced Simulation Forchungszentrum Jülich,Jülich, Germany

Nanostructures of 3d transition metals on 4d or 5d substrates have been shown to exhibit complex spin structures [1-4]. A recent study demonstrated the intriguing magnetism of Fe biatomic chains on the (5x1) reconstructed Ir(001) surface due to the interplay of magnetocrystalline anisotropy, Dzyaloshinskii-Moriya interaction and exchange interaction [4]. Here, we use first-principles calculations based on density functional theory to explore Co biatomic chains on the (5x1) Ir(001) surface. Due to the key role of 3d-5d hybridization for the magnetic properties of such systems [5], we study Co chains in different structural arrangements and the impact of structural relaxations. We report the magnetic properties of the Co chains such as the magnetocrystalline anisotropy energy and the spatial distribution of spin-polarization. We compare our results with recent spin-polarized STM experiments [6].

[1] B. Hardrat et al. PRB 79, 094411 (2009) [2] S. Heinze et al. Nature Phys. 7, 713 (2011) [3] Y. Yoshida et al., PRL 108, 087205 (2012) [4] M. Menzel et al PRL, 108, 197204 (2012) [5] S. Baud et al Phys. Rev. B 73, 104427 (2006) [6] J. Bickel, K. et al to be published

MA 45: Magnetic Coupling and Spin Structures

Time: Thursday 15:00–18:45 Location: H10

MA 45.1 Thu 15:00 H10

Direct spectroscopic observations of non-rotatable magnetic moments in Fe50Mn50/Co bilayer using XMCD — •Patrick Audehm, Mathias Schmidt, Gisela Schütz, and Eberhard Goering — MPI for Intelligent Systems, formerly MPI for Metals Research, Stuttgart, Germany

The XMCD (X-ray Magnetic Circular Dichroism) is a unique tool for small microscopic magnetic moments, which allows to identify even the smallest fraction of magnetic moments in an element specific way and their separation in spin and orbital contributions. By a double rotation of polarization and magnetization, the dichroic signal is sensitive to non-rotatable magnetic moments. We have performed highly sensitive XMCD studies on a Exchange Bias (EB) system with Fe50Mn50 and

Co layer on top. Our transition metal L2,3 edge XMCD analysis of the top (FM) and the underlying FeMn layer (AF) for rotatable magnetic moments provides the pure-metal like spin dominated XMCD spectra. In contrast to this, the non-rotatable moment*s spectra exhibit a nearly pure orbital character. In order to prove this spectacular result, we have verifyed the temperature dependency of this effect, with reduced EB at higher temperature. These experiments point towards the existence of locally loaded spin-orbit-coupling springs on the atomic level. This result is of great importance and has to be considered beyond EB systems as a local source for anisotropy energy in transition metal compounds.

MA 45.2 Thu 15:15 H10

Studies on thermal activation of CoFe/MnIr exchange bias layer systems — Timo Ueltzhöffer, •Henning Huckfeldt, Alexander Gaul, and Arno Ehresmann — Center for Interdisciplinary Nanostructure Science and Technology (CINSaT) and Department of Physics, University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Exchange bias layer systems consisting of 10 nm $Mn_{83}Ir_{17}$ and 6.5 nm $Co_{70}Fe_{30}$ deposited by RF-sputter deposition were analyzed systematically concerning the temperature dependence on the activation of the antiferromagnet and the exchange bias coupling parameters. The results will be presented in comparison to those published by O'Grady *et al.*[1]

A general insight into the blocking temperature distribution was achieved. In addition, competitive effects like interface diffusion could be clearly identified, starting well below the Néel-temperature. Using these measurements a controlled setting of the antiferromagnet can be achieved leading to reproducible sample parameters and measurements.

[1] K. O'Grady, L.E. Fernandez-Outon and G. Vallejo-Fernandez, *J. Magn. Magn. Mat.*, 322, 883 (**2010**).

MA 45.3 Thu 15:30 H10

Effect of CoO/Ni exchange coupling on perpendicular magnetization of Ni films on Pd(001) — •Piotr Kuświk[1], Pedro L. Gastelois[1,2], Waldemar A. A. Macedo[2], Marek Przybylski[1,3], and Jürgen Kirschner[1,4] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Centro de Desenvolvimento da Tecnologia Nuclear, Belo Horizonte, Brazil — [3]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [4]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

The exchange bias effect has been widely investigated in systems presenting in-plane anisotropy. Even more important candidates for developing new technologies are the systems combining magnetic out-of-plane anisotropy and perpendicular exchange bias. We have shown that CoO/Ni bilayer epitaxially grown on Pd(001) exhibits not only the perpendicular magnetization, but also the perpendicular exchange bias effect. Moreover, after cooling it down to T=5K, the initially in-plane easy magnetization axis of the Ni underlayers in the thickness range of 17-25ML, exhibits not only strong exchange coupling, but also perpendicular anisotropy. The coupling at the CoO/Ni interface is indicated by strongly enhanced coercivity with respect to the uncovered Ni films, and exchange bias field of 200Oe. At T=290K, coercivity decreases to the value for the uncovered Ni films and exchange bias disappears, which indicates that coupling exists only below the Néel temperature of CoO.

MA 45.4 Thu 15:45 H10

Exchange Bias effect in coupled systems of ferrimagnetic $Fe_{100-x-y}Co_xTb_y$ and ferromagnetic $[Co(0.4nm)/Pt(0.8nm)]_{10}$-multilayers — •Birgit Hebler[1], Christian Schubert[1], Florin Radu[2], and Manfred Albrecht[1] — [1]Institute of Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]Hemholtz-Zentrum Berlin für Materialen und Energie, D-12489 Berlin, Germany

A large exchange bias effect is an important aspect in the miniaturizing of prospective spintronic devices. In this regard out-of-plane anisotropy heterostructures consisting of amorphous ferrimagnetic (FI) rare-earth/transition metal alloys and ferromagnetic (FM)[Co/Pt]-multilayer stacks attracted much attention due to the occurance of a large exchange bias field of about 10 kOe [1]. In our study we prepared FI/FM bilayers of $Fe_{100-x-y}Co_xTb_y$ (20nm) and a $Co(0.4nm)/Pt(0.8nm)]_{10}$-multilayer stack by magnetron-sputtering in a UHV-chamber at room temperature. We measured the magnetization reversal processes at different temperatures by using a SQUID-VSM to analyse how the variation of the composition of the ternary alloy influences the magnetic exchange interactions at the interface and consequently the exchange bias field.

[1] S. Romer et al., Appl. Phys. Lett. 101, 222404 (2012)

MA 45.5 Thu 16:00 H10

Crystallite size determination of exchange biased thin film systems with the Guinier camera *Huber G 653* — •Markus Meyl 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

Exchange biased thin film systems are structurally characterised with the X-ray Guinier thin film camera *Huber G 653*. One advantage of this Guinier camera includes the use of a focussing monochromator between the X-ray tube and the thin film system for achieving strictly monochromatic X-rays. Another benefit lies in the very small angle of incidence ($< 10°$) between the incident X-rays and the surface of the sample to achieve a large effective distance in the thin films and thereby higher diffraction intensities. The measurement geometry behind the monochromator is called Seemann-Bohlin geometry. In this geometry the focal line of the monochromator, the surface of the sample and the detector entrance slit are located on a constant focussing cylinder. During one measurement the angle of incidence is constant and the detector entrance slit moves on the focussing cylinder. Reflected X-rays are measured when Bragg's law is fulfilled. As a consequence the Guinier thin film goniometer is especially suitable for analysing thin polycrystalline films on a crystalline or amorphous substrate. From the diffraction spectrum e.g. crystallite sizes can be calculated using Fourier analysis. Exemplary results of exchange biased thin film systems deposited by RF-sputtering will be presented.

MA 45.6 Thu 16:15 H10

Direct manipulation of the uncompensated antiferromagnetic spins — •Amitesh Paul[1], Neelima Paul[2], Stefan Mattauch[3], and Peter Böni[1] — [1]Technische Universität München, Physik Department E21, — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, — [3]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH,

Incident ion energy to matrix electrons of a material is dissipated within a narrow cylinder surrounding the swift heavy ion path. The temperature of the lattice exceeds the melting point and upon quenching causes nanometric modifications. We present here a unique ex situ approach in manipulating the uncompensated spins in antiferromagnetic layers of ferro-/antiferromagnetic (CoO-Co) exchange coupled systems on a nanometric scale. We use the impact of relativistic heavy ion (1-2 GeV) irradiation on such systems. We find an increase in the bias field and a restoration of the reversal via domain nucleation in the trained state. These are identified as plausible results of ion-induced antiferromagnetic ordering with little or no effect on the layer structure. This study demonstrates, therefore, the possibility of nanoscale tailoring of exchange coupled systems that survive even in the trained state.

15 min. break

MA 45.7 Thu 16:45 H10

^{57}Fe NMR as a local probe for chiral ferromagnetism in non-centrosymmetric FeGe — •Michael Baenitz[1], Panchanan Khuntia[1], Markus Schmidt[1], Ulrich Roessler[2], and Heribert Wilhelm[3] — [1]Max-Planck-Institute for the Chemical Physics ofSolids, 01187 Dresden, Germany — [2]Leibniz Institutefor Solid State and Materials Research - IFW, 01171 Dresden, Germany — [3]Diamond Light Source Ltd, Didcot, OxfordshireOX11 0DE, United Kingdom

The helical ferromagnet FeGe belongs to the class of B20 compounds with non-centrosymmetric structure being essential for new forms of ferromagnetic phases (confined or modulated Skyrmion phase). From an NMR point FeGe is a prototype system to study chiral excitations directly "on-site" via the ^{57}Fe nucleus which (in contrast to ^{55}Mn with nuclear spin S=5/2) has a spin of S=1/2 with the big advantage of an absent quadrupolar interaction which usually creates broad NMR lines and prevents detailed investigations of the anisotropic Zeeman interaction in internal/external fields. ^{57}Fe NMR opens up to probe the local susceptibility (hyperfine field), the dynamic susceptibility (spin lattice relaxation rate) and the spin-spin interaction directly "on site".

Additionally the NMR line itself (its Fourier transform) provides information about the multiplicity of the Fe sites in the complex helimagnet. ^{57}Fe NMR was performed on crushed single crystals of ^{57}Fe enriched FeGe material between 2-300 K in zero and applied magnetic fields. Phase boundaries in the ordered state are identified and interestingly critical dynamics in the vicinity of these boundaries are obtained from the spin-lattice and spin-spin relaxation rate.

MA 45.8 Thu 17:00 H10

Spindynamics in $CaBaCo_2Fe_2O_7$ under strong geometrical frustration — •Johannes Reim[1], Lars Fritz[2], Martin Valldor[3], and Werner Schweika[1] — [1]JCNS-2 and PGI-4, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany — [3]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany

Recent studies of spin correlations in materials belonging to the swedenborgite compound family ($P6_3mc$)[1] exhibit signs of unusual strong geometric frustration: at low temperatures, indications for quasi 2D spin correlations, spin glass/liquid states, and also rather complex, partly ordered ground states have been observed.[2-3] Several groups have investigated this compound family with different stoichiometry, mainly focusing on solving structural and ground state configurations (f.e. [4]). Since the material characteristics are dominated by the strong magnetic frustration, excitations are very sensitive to small changes in ordering and exchange interactions. We will present neutron inelastic scattering on a single crystal of the compound $CaBaCo_2Fe_2O_7$, that have been obtained from triple axis (PANDA) and thermal time-of-flight scattering (ARCS). The experimental results will be discussed in comparison with theoretical calculations of the phase diagram and the spin dynamics based on nearest neighbor Heisenberg models.

[1] M. Valldor and M. Andersson. Solid State Sci. 4(7):923-931 (2002)
[2] W. Schweika et al. Phys. Rev. Lett., 98(6):067201 (2007)
[3] D. D. Khalyavin et al. Phys. Rev. B, 82(9):094401 (2010)
[4] A. Huq et al. J. Solid State Chem., 179(4):1136-1145 (2006)

MA 45.9 Thu 17:15 H10

Slow magnetic order-order transition in antiferromagnet $Ca_3Co_2O_6$ — •Stefano Agrestini[1], Martin Lees[2], Catherine Fleck[2], Laurent Chapon[3], and Claudio Mazzoli[4] — [1]Max Planck Institut für Chemische Physik fester Stoffe, Dresden, Germany — [2]Physics Department, University of Warwick, Coventry, UK — [3]ILL, Grenoble, France — [4]Politecnico di Milano, Milano, Italia

Time-dependent phenomena play a crucial role in the properties of many magnetic systems, including spin-glasses, single-molecule magnets and superparamagnets. However time-dependent magnetism is not expected to be observed in the presence of long-range magnetic order. Here we challenge this view by reporting the observation of a new time-dependent behavior where a transition from one long-range magnetically ordered state to another occurs in zero magnetic field over a time scale of several hours. We performed an extensive neutron diffraction study of the spin chain system $Ca_3Co_2O_6$ whose step-like magnetization versus magnetic field aroused great interest in the scientific community. Our data show that for T< 14K< T_N =25K the spin-density-wave order observed immediately below T_N, becomes unstable and a commensurate antiferromagnetic phase appears via a very slow transformation process. As the temperature is reduced the characteristic time of the transition process increases rapidly and at low temperatures the magnetic states become frozen. The transition is also noteworthy because the two phases have different propagation vectors. Very rarely transitions between two magnetically ordered phases involve a change of translational symmetry.

MA 45.10 Thu 17:30 H10

The phase diagram of the quantum spin-2 XXZ chain with on-site anisotropy — •Jonas A. Kjäll[1,2], Michael P. Zaletel[1], Roger S. K. Mong[1,3], Jens H. Bardarson[1,4], and Frank Pollmann[2] — [1]Department of Physics, University of California, Berkeley, California 94720, USA — [2]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany — [3]Department of Physics, California Institute of Technology, Pasadena, CA 91125, USA — [4]Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

How the highly quantum mechanical phase diagrams at small spin is connected with the classical (infinite spin) phase diagrams is interesting for many models. We focus on a particular problem, the ground state phase diagram of the quantum spin-2 XXZ chain in the presence of on- site anisotropy. We use a state of the art infinite system density-matrix-renormalization- group (iDMRG) algorithm and show how many challenging phases and phase transitions in quantum spin systems can be accurately detected. Different types of on-site anisotropies are considered, allowing us to establish the validity of the following statements: One, the spin-2 model can be tuned into a phase which is equivalent to the "topologically nontrivial" spin-1 Haldane phase. Two, the spin-2 Haldane phase at the isotropic Heisenberg point is adiabatically connected to the "trivial" large-D phase, with a continuous change of the Hamiltonian parameters. Furthermore, we study the spin-3 XXZ chain to help explain the development of the classical phase diagram.

MA 45.11 Thu 17:45 H10

Investigation of the electronic structure of Cr using the 2D-ACAR technique — •Hubert Ceeh[1], Josef-Andreas Weber[1], Michael Leitner[2], Christoph Hugenschmidt[1,2], Liviu Chioncel[3], and Peter Böni[1] — [1]Technische Universität München, Physik Department E21, D-85748 Garching, Germany — [2]FRM II, Technische Universität München, D-85747 Garching, Germany — [3]University of Augsburg, Theoretical Physics III, D-86135 Augsburg, Germany

Almost all properties of a material are defined by its electronic structure. For a metal, the most important characteristic is the Fermi surface, defining the boundary between occupied and unoccupied states in reciprocal space. The traditional experimental method for studying the Fermi surface is the de Haas-van Alphen effect, which is limited to low temperatures, and therefore cannot be utilized for the study of paramagnetic Cr above the Néel temperature of Cr is 311 K. For this reason, we applied the 2D-ACAR (Angular Correlation of Positron Annihilation Radiation) technique to investigate the electronic structure of both, the paramagnetic and the anti-ferromagnetic phase of Cr. We present the key features of our 2D-ACAR spectrometer and discuss the measurements on the pure metal system Cr, which are also compared with first principle band structure calculations.
This project is funded by the Deutsche Forschungsgesellschaft (DFG) within the Transregional Collaborative Research Center TRR 80 "From electronic correlations to functionality"

MA 45.12 Thu 18:00 H10

ARPES insight into the electronic and magnetic properties of $EuRh_2Si_2$ — •Alla Chikina[1], Silvia Seiro[3], Marc Höppner[1,2], Monika Güttler[1], Steffen Danzenbächer[1], Kurt Kummer[1,4], Yuri Kucherenko[5], Christoph Geibel[3], Ming Shi[6], Luc Patthey[6], Sergey Molodtsov[7], Clemens Laubschat[1], and Denis Vyalikh[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, D-01062, Germany — [2]Max-Planck Institut für Festkörperphysik, Heisenbergstr. 3,D-70569 Stuttgart, Germany — [3]Max-Plank-Institut für Chemische Physic fester Stoffe, Nöthnitzer Straß e 40, D-01187 Dresden, Germany — [4]European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble Cedex, France — [5]Institute for Metal Physics, National Academy of Sciences of Ukraine, UA-03142 Kiev, Ukraine — [6]Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen-PSI, Switzerland — [7]European XFEL GmbH, Albert-Einstein Ring 19, D-22671 Hamburg, Germany

Eu-based intermetallics exhibit interesting low-temperature physics, covering magnetism and mixed-valent behaviour due to delicate interplay between localized 4f and conduction electrons. By doing the photoemission (ARPES) experiments and supplementing them by LDA-based slab- and bulk- band structure calculations, we perform the comprehensive analysis of the electronic and magnetic properties of divalent $EuRh_2Si_2$ system. In the present work we will discuss f-d hybridization phenomena as well as the modification of the electronic structure upon the phase transition from paramagnetic into the antiferromagnetic phase.

MA 45.13 Thu 18:15 H10

Magnetization reversal in Nd-Fe-B based nanocomposites as seen by magnetic neutron scattering — •Jens-Peter Bick[1], Dirk Honecker[1], Frank Döbrich[1], Kiyonori Suzuki[2], Elliot Gilbert[3], Henrich Frielinghaus[4], Joachim Kohlbrecher[5], Jorge Gavilano[5], Edward Forgan[6], Ralf Schweins[7], Peter Lindner[7], Rainer Birringer[8], and Andreas Michels[1] — [1]University of Luxembourg, Luxembourg — [2]Monash University, Australia — [3]ANSTO, Australia — [4]JCNS, Germany — [5]PSI, Switzerland — [6]University of Birmingham, United Kingdom — [7]ILL, France

— [8]Universität des Saarlandes, Germany

We have studied the magnetization-reversal process of a $Nd_2Fe_{14}B/Fe_3B$ nanocomposite using small-angle neutron scattering. Based on the computation of the autocorrelation function of the spin misalignment we have estimated the characteristic size l_C of spin inhomogeneities around the $Nd_2Fe_{14}B$ nanoparticles. The quantity l_C approaches a constant value of about 12.5 nm ($\sim$ average $Nd_2Fe_{14}B$ particle radius) at 14 T and takes on a maximum value of about 18.5 nm at the coercive field of -0.55 T. The field dependence of l_C can be described by a model that takes into account the convolution relationship between the nuclear and magnetic microstructure.

MA 45.14 Thu 18:30 H10

Fictitious excitations in the classical Heisenberg antiferromagnet on the kagome lattice — •Stefan Schnabel[1] and David P. Landau[2] — [1]Universität Leipzig — [2]University of Georgia, USA

In the last decades the classical Heisenberg antiferromagnet on the kagome lattice has been subject of a number of theoretical and numerical studies and today its behavior is widely understood. A prominent feature is 'ordering by disorder' meaning the entropy-driven formation of a highly degenerate coplanar state at low temperature. There remain, however, a few open questions. For the coplanar regime analytical investigations predict an acoustic branch of spin waves, while a recent numerical study [1] using standard spin dynamics techniques suggests the existences of additional optical modes. We show how this discrepancy arises from different descriptions of the system and demonstrate that the structure of the low-temperature state causes shifts in Fourier space, thus creating a fictitious optical branch. Furthermore, we applied an advanced Monte Carlo method in combination with spin dynamics simulations of high precision and found very good agreement with the theoretical results regarding the dynamic behavior at low temperatures.

[1] J. Robert, B. Canals, V. Simonet, and R. Ballou, Phys. Rev. Lett. **101**, 117207 (2008).

[2] S. Schnabel and D. P. Landau, Phys. Rev. B **86**, 014413 (2012).

MA 46: Topological Insulators 5 (jointly with DS, HL, MA, and O)

Time: Friday 9:30–13:00 Location: H18

MA 46.1 Fri 9:30 H18

Structure factor of a weakly interacting helical liquid — •Suhas Gangadharaiah[1,2], Thomas L. Schmidt[2], and Daniel Loss[2] — [1]Indian Institute of Science Education and Research, Bhopal, India — [2]Department of Physics, University of Basel, CH-4056 Basel, Switzerland

We calculate the density structure factor $S(q,\omega)$ of a weakly interacting helical liquid in the presence of a magnetic field B. The latter opens a gap of width $2B$ in the single-particle spectrum $\epsilon_\pm(k)$, and leads to a strongly nonlinear spectrum near $k = 0$. For chemical potentials $\mu > B$, the system then behaves as a nonlinear helical Luttinger liquid, and a mobile-impurity analysis reveals interaction-dependent power-law singularities in $S(q,\omega)$. For $\mu < B$, the low-energy excitations are gapped, and we determine $S(q,\omega)$ by using an analogy to exciton physics. We discuss the implications of the magnetic field induced non-linear spectrum on the Coulomb drag between the helical liquids.

MA 46.2 Fri 9:45 H18

Strongly interacting Majorana modes in an array of Josephson junctions — Fabian Hassler[1] and •Dirk Schuricht[2] — [1]Institute for Quantum Information, RWTH Aachen University — [2]Institute for Theory of Statistical Physics, RWTH Aachen University

An array of superconducting islands with semiconducting nanowires in the right regime provides a macroscopic implementation of Kitaev's toy model for Majorana wires. We show that a capacitive coupling between adjacent islands leads to an effective interaction between the Majorana modes. We demonstrate that even though strong repulsive interaction eventually drive the system into a Mott insulating state the competition between the (trivial) band-insulator and the (trivial) Mott insulator leads to an interjacent topological insulating state for arbitrary strong interactions.

MA 46.3 Fri 10:00 H18

All-electrical measurement of crossed Andreev reflection in topological insulators — •Rolf W. Reinthaler[1], Patrik Recher[2], and Ewelina M. Hankiewicz[1] — [1]Faculty of Physics and Astrophysics, University of Würzburg, Würzburg, Germany — [2]Institute for Mathematical Physics, Technical University Braunschweig, Braunschweig, Germany

Using a generalized wave matching method we solve the full scattering problem for quantum spin Hall insulator (QSHI) - superconductor (SC) - QSHI junctions. We find that for systems narrow enough so that the bulk states in the SC part couple both edges, the crossed Andreev reflection (CAR) is significant and the electron cotunneling (T) and CAR become spatially separated. We study the effectiveness of this separation as a function of the system geometry and the level of doping in the SC. Moreover, we show that the spatial separation of both effects allows for an all-electrical measurement of CAR and T separately in a 5-terminal setup or by using the spin selection of the quantum spin Hall effect in an H-bar structure [1].

We acknowledge financial support by the DFG grant HA 5893/3-1.

[1] R. W. Reinthaler, P. Recher, and E. M. Hankiewicz, arXiv:1209.5700 (2012)

MA 46.4 Fri 10:15 H18

Zero-voltage conductance peak from weak antilocalization in a Majorana nanowire — •Michael Wimmer[1], Dimitri Pikulin[1], Jan Dahlhaus[1], Henning Schomerus[2], and Carlo Beenakker[1] — [1]Instituut-Lorentz, Universiteit Leiden, The Netherlands — [2]Department of Physics, Lancaster University, United Kingdom

We show that weak antilocalization by disorder competes with resonant Andreev reflection from a Majorana zero-mode to produce a zero-voltage conductance peak of order e^2/h in a superconducting nanowire. The phase conjugation needed for quantum interference to survive a disorder average is provided by particle-hole symmetry - in the absence of time-reversal symmetry and without requiring a topologically nontrivial phase. We identify methods to distinguish the Majorana resonance from the weak antilocalization effect.

MA 46.5 Fri 10:30 H18

Spectral properties of disordered multi-channel Majorana wires — •Patrick Neven, Dmitry Bagrets, and Alexander Altland — Institut für Theoretische Physik, Universität zu Köln, Köln, Germany

Proximity coupled multi-channel spin-orbit quantum wires may support midgap Majorana states at the ends. We study the fate of these Majorana fermions in the presence of disorder in such wires. Inspired by the widely established theoretical methods of mesoscopic superconductivity, we develop a quasiclassical approach which is valid in the limit of strong spin-orbit coupling. A numerical solution of the Eilenberger equation reveals that disordered topological wires are prone to the formation of a zero-energy anomaly (class D impurity spectral peak) in the local density of states which shares the key features of a Majorana peak. We also find that the $\mathbb{Z}_2$ topological invariant distinguishing between the state with and without Majorana fermions (symmetry class B and D, resp.) is related to the Pfaffians of quasiclassical Green's functions.

MA 46.6 Fri 10:45 H18

Topological invariants and interacting one-dimensional fermionic systems — •Salvatore R. Manmana[1,2,3], Andrew M. Essin[3], Reinhard M. Noack[4], and Victor Gurarie[3] — [1]Institut für Theoretische Physik, Universität Göttingen, Germany — [2]JILA, University of Colorado and NIST, Boulder (CO), USA — [3]Department of Physics, University of Colorado at Boulder, USA — [4]Fachbereich Physik, Philipps-Universität Marburg, Germany

We study one-dimensional, interacting, gapped fermionic systems described by variants of the Peierls-Hubbard model, and we characterize their phases via a topological invariant constructed out of their

Green's functions. We demonstrate that the existence of topologically protected, zero-energy states at the boundaries of these systems can be tied to the value of the topological invariant, just like when working with the conventional, non-interacting topological insulators. We use a combination of analytical methods and the numerical density matrix renormalization group method to calculate the values of the topological invariant throughout the phase diagrams of these systems, thus deducing when topologically protected boundary states are present. We are also able to study topological states in spin systems because, deep in the Mott insulating regime, these fermionic systems reduce to spin chains. In this way, we associate the zero-energy states at the end of an antiferromagnetic spin-1 Heisenberg chain with a topological invariant equal to 2.

MA 46.7 Fri 11:00 H18

Fluctuation driven topological Hund insulator — •Jan Carl Budich[1], Bjoern Trauzettel[2], and Giorgio Sangiovanni[2] — [1]Department of Physics, Stockholm University, Se-106 91 Stockholm, Sweden — [2]Institute for theoretical physics and astrophysics, 97074 Würzburg, Germany

We investigate in the framework of dynamical mean field theory a two-band Hubbard model based on the Bernevig-Hughes-Zhang Hamiltonian describing the quantum spin Hall (QSH) effect in HgTe quantum wells. In the presence of interaction, we find that a system with topologically trivial non-interacting parameters can be driven into a QSH phase at finite interaction strength by virtue of local dynamical fluctuations. For very strong interaction, the system reenters a trivial insulating phase by going through a Mott transition. We obtain the phase diagram of our model by direct calculation of the bulk topological invariant of the interacting system in terms of its single particle Green's function.

15 min. break

MA 46.8 Fri 11:30 H18

Floquet Topological Quantum Phase Transitions in the Wen-Plaquette Model — •Victor Manuel Bastidas Valencia, Clive Emary, Gernot Schaller, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Our aim in this talk is to describe the nonequilibrium behavior of the topological quantum phase transition in the Ac-driven Wen-plaquette model. We show that under the effect of a nonadiabatic driving the system exhibits a novel topological phase. We define generalized topological order parameters by considering cycle-averaged expectation values of string operators in a Floquet state.

MA 46.9 Fri 11:45 H18

Fermion-parity anomaly of the critical supercurrent in the quantum spin-Hall effect — •Jan Dahlhaus[1], Dmitry Pikulin[1], Timo Hyart[1], Henning Schomerus[2], and Carlo Beenakker[1] — [1]Instituut-Lorentz, Universiteit Leiden, Niederlande — [2]Department of Physics, Lancaster University, United Kingdom

The helical edge state of a quantum spin-Hall insulator can carry a supercurrent in equilibrium between two superconducting electrodes (separation L, coherence length ξ). We calculate the maximum (critical) current I_c that can flow without dissipation along a single edge, going beyond the short-junction restriction $L \ll \xi$ of earlier work, and find a dependence on the fermion parity of the ground state when L becomes larger than ξ. Fermion-parity conservation doubles the critical current in the low-temperature, long-junction limit, while for a short junction I_c is the same with or without parity constraints. This provides a phase-insensitive, dc signature of the 4π-periodic Josephson effect.

MA 46.10 Fri 12:00 H18

Topological kicked rotators — •Jan Dahlhaus[1], Jonathan Edge[1], Jakub Tworzydlo[2], and Carlo Beenakker[1] — [1]Instituut-Lorentz, Universiteit Leiden, Niederlande — [2]Institute of Theoretical Physics, University of Warsaw, Poland

Topology is a nice mathematical concept that can have profound consequences on condensed matter systems. Maybe the most prominent examples are the quantum Hall effect, the quantum spin Hall effect and the 3D topological insulator. I will present a way to realize the ideas of band topology in a well-known and intensively-studied model - the quantum kicked rotator. This allows to study the Anderson localization properties of topological phase transitions numerically in a very efficient way, especially in higher dimensions. Furthermore it may open a way for experimental measurements of this transition behaviour with cold atomic gases in optical lattices.

MA 46.11 Fri 12:15 H18

Theory of correlated topological insulators with broken axial spin symmetry — •Stephan Rachel — TU Dresden, 01069 Dresden, Germany

The two-dimensional Hubbard model defined for topological band structures exhibiting a quantum spin Hall effect poses fundamental challenges in terms of phenomenological characterization and microscopic classification. We consider weak, moderate, and strong interactions and argue that the resulting phase diagrams depend on the microscopic details of the spin orbit interactions which give rise to the non-trivial topology. In particular, it turns out that there is a crucial difference between models with broken and with conserved axial spin symmetry. These results suggest that there is a general framework for correlated 2D topological insulators with broken axial spin symmetry.

[1] Rachel, LeHur, PRB 82, 075106 (2010)
[2] Schmidt, Rachel, von Oppen, Glazman, PRL 108, 156402 (2012)
[3] Cocks, Orth, Rachel *et al.*, PRL 108, 205303 (2012)
[4] Reuther, Thomale, Rachel, PRB 86, 155127 (2012)

MA 46.12 Fri 12:30 H18

Interaction effects on almost flat surface bands in topological insulators — •Matthias Sitte, Lars Fritz, and Achim Rosch — Universität zu Köln, Institut für Theoretische Physik, Zülpicher Str. 77, 50937 Köln, Deutschland

We investigate ferromagnetic instabilities of the two-dimensional helical Dirac fermions hosted on the surface of three-dimensional topological insulators. We concentrate on ways to increase the role of interactions by means of modifying the bulk properties which in turn changes the surface Dirac theory characteristics. We discuss both long-ranged Coulomb interactions controlled by the dimensionless coupling constant $\alpha = e^2/(\hbar\epsilon v_F^{\mathrm{surf}})$ as well as short-ranged Hubbard-like interactions of strength U which can induce spontaneous surface ferromagnetism, thereby gapping the surface Dirac metal. In both cases, we find that a prerequisite for observing this effect is to reduce the Fermi velocity v_F^{surf}, and we consider different mechanisms to achieve this. While for long-ranged Coulomb interactions we find that screening hinders ferromagnetism, for short-ranged interactions screening is not that vital and the instability can prevail.

MA 46.13 Fri 12:45 H18

Local spin susceptibility and surface states in doped three-dimensional topological insulators with odd-parity superconducting pairing symmetry — •Björn Zocher[1,2] and Bernd Rosenow[1] — [1]Institut für Theoretische Physik, Universität Leipzig, D-04103 Leipzig, Germany — [2]Max Planck Institut für Mathematik in den Naturwissenschaften, D-04103 Leipzig, Germany

We investigate characteristic features in the spin response of doped three-dimensional topological insulators with odd-parity unequal-spin superconducting pairing. To get insight into the nature of the superconducting pairing symmetry, we show that the odd-parity unequal-spin pairing can be mapped onto p-wave pairing and that these systems have gapless Majorana surface modes. The Majorana modes contribute to the local spin susceptibility, giving rise to a characteristic temperature behavior of the Knight shift and the spin-lattice relaxation time in magnetic resonance experiments. Because of their different decay lengths, the Majorana modes can be observed and clearly distinguished from the Dirac modes of the topological insulator by local probes which allow for a depth-controlled study of the electron spins on the nanometer length scale.

MA 47: Transport: Spintronics, Magnetotransport 2 (jointly with HL&MA)

Time: Friday 9:30–10:30 Location: H20

MA 47.1 Fri 9:30 H20

Bulk sensitive photoelectron spectroscopy on CrO_2 thin films — •Jonas Weinen[1], Stefano Agrestini[1], Martin Rotter[1], Simone G. Altendorf[1], Zhiwei Hu[1], Chun-Fu Chang[1], Arun Gupta[2], Yen Fa Liao[3], Ku-Ding Tsuei[3], and Liu Hao Tjeng[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden — [2]The University of Alabama, Tuscaloosa, USA — [3]National Synchrotron Radiation Research Centre, Hsinchu, Taiwan

For transition metal compounds with a high oxidation state the so-called charge transfer energy can become negative, with the result that a spontaneous electron redistribution could occur in which oxygen holes are formed. Such seems to be the case for the ferromagnet CrO_2. Using the LDA+U method, Korotin et al. [PRL **80**, 4305 (1998)] calculated that the material is a metal and remains a metal even for very large values of U. This suggests that it is not so much the Cr 3*d* states that determine whether the system is metallic or insulating, but rather that it is the O 2*p* states which straddle the chemical potential.—Several photoelectron spectroscopy (PES) studies have been reported in the literature, but the results are not consistent, supposedly related to the fact that the surface of CrO_2 tends to decompose to Cr_2O_3 under vacuum conditions, so that surface sensitive PES may not have probed the true bulk spectrum of CrO_2.—We set out to perform bulk sensitive photoemission experiments below and above T_C on CrO_2 thin films using our HAXPES system at SPring-8. Our results suggest that CrO_2 may be considered more like a bad metal rather than a normal metal.

This work is also supported by DFG through FOR1346.

MA 47.2 Fri 9:45 H20

Initial stages of epitaxial growth of Fe_3O_4/MgO (001) thin films: atomic reconstruction at the polar interface — •Chun-Fu Chang[1], Zhiwei Hu[1], Stefan Klein[2], Ronny Sutarto[2], Philipp Hansmann[2], Arata Tanaka[3], Julio Criginski Cesar[4], Nicholas Brookes[4], Hong-Ji Lin[5], Hui-Huang Hsieh[6], Chien-Te Chen[5], A. Diana Rata[1], and Liu Hao Tjeng[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]II. Physikalisches Institut, Universität zu Köln, Köln, Germany — [3]Department of Quantum Matter, ADSM, Hiroshima University, Hiroshima, Japan — [4]ESRF, Grenoble Cédex, France — [5]NSRRC, Hsinchu, Taiwan — [6]Chung Cheng Institute of Technology, National Defense University, Taoyuan, Taiwan

By means of reflection high energy electron diffraction and Fe $L_{2,3}$ x-ray absorption spectroscopy we find evidence for an atomic structural reconstruction at the interface of polar Fe_3O_4/MgO (001) thin films. This reconstruction takes place over several monolayers, while each monolayer still preserves the Fe_3O_4 stoichiometery. Our findings for such a transition interface layer may have important implications especially in the field of spintronics, where ultrathin Fe_3O_4 films are widely used for various sensitive devices.

MA 47.3 Fri 10:00 H20

Investigation of the Verwey transition in Fe_3O_4 thin films — •Xionghua Liu, Akfiny Hasdi Aimon, A. Diana Rata, Chun-Fu Chang, and Liu Hao Tjeng — Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

Magnetite Fe_3O_4 is one of the most investigated materials from the class of transition metal oxides. It shows a first-order anomaly in the temperature dependence of the electrical conductivity at T_V= 120 K, the famous Verwey transition. However, thin films of Fe_3O_4 show always a lower T_V compared to the bulk material. In order to find out the reason for the decreased T_V in magnetite thin films we have performed a systematic investigation of the transport properties in dependence of the oxygen pressure and thickness. Epitaxial Fe_3O_4 films were grown by Molecular Beam Epitaxy on MgO(100) and $MgAl_2O_4$ (100) substrates and the structural and spectroscopic characteristics were in-situ determined by RHEED and XPS, respectively. Resistivity measurements have been performed ex-situ by PPMS. Results of this study and ongoing work will be presented.

MA 47.4 Fri 10:15 H20

Electronic Structure and Magnetic Properties of Sc doped EuO Thin Films — •Andreas Reisner[1], Simone Altendorf[1], Chun-Fu Chang[1], Hong-Ji Lin[2], Chien-Te Chen[2], and Liu Hao Tjeng[1] — [1]Max-Planck-Institute for Chemical Physics of Solids, Nöthnitzer Str.40, 01187 Dresden, Germany — [2]National Synchrotron Radiation Research Center, Hsin-Ann Road, 30076 Hsinchu, Taiwan, R.O.C.

Europium monoxide is a ferromagnetic semiconductor with a Curie temperature T_C of 69 K. Upon doping the material can show an increase of the Curie temperature, a metal-to-insulator transition and a high spin polarization of the charge carriers. Applying pressure can also enhance T_C. Mostly other trivalent rare earth metals are used as dopant. Here we set out to explore the possibility of using transition metals as dopants. As a start we focus on the non magnetic Sc ions. We are able to achieve excellent crystalline growth of Sc-doped EuO thin films on YSZ (001) substrates using molecular beam epitaxy. We will report our results on the crystal structure as characterized by RHEED and LEED, the electronic structure as determined by XPS and ARPES, and on the magnetic propertes as measured by SQUID.

MA 48: Spin-dependent Transport Phenomena

Time: Friday 9:30–12:45 Location: H23

MA 48.1 Fri 9:30 H23

Electrical detection of inverse spin Hall effect induced by spin pumping — •Yuriy Aleksandrov[1,2], Jürgen Lindner[1], Michael Farle[3], Irina Rod[3], and Horst Zähres[3] — [1]HZDR, Dresden, Germany — [2]TU Dresden, Dresden, Germany — [3]Universität Duisburg-Essen, Duisburg, Germany

Spin pumping driven by ferromagnetic resonance (FMR) injects a spin current through a simple ferromagnetic (FM)/paramagnetic (PM) interface into a PM layer [1]. Due to the inverse spin Hall effect (ISHE), arising from the spin-orbit coupling in the PM layer, the spin current is converted into a charge current. As a result transverse electromotive force perpendicular to the applied magnetic field and to the microwave field is produced [2]. Here we present direct measurements of the ISHE induced by spin pumping in Py/Pt bilayer. We observe a 4mT FMR linewidth broadening for the samples with Pt capping layers due to spin pumping. We also find that the electromotive force varies systematically with changing microwave power and frequency, magnetic-field angle, or temperature. This is consistent with the predictions based on the Landau-Lifshitz-Gilbert equation combined with the models of the ISHE and spin pumping.

Financially suppoted by DFG, SFB 491.

[1]Tserkovnyak et al. PRL., 88:117601, Feb 2002.
[2]Mosendz et al. PR B 82, 214403, 2010

MA 48.2 Fri 9:45 H23

Spin-Hall effect in 4*d* and 5*d* transition metal systems — •Kristina Chadova, Diemo Ködderitzsch, and Hubert Ebert — Universität München, Department Chemie, Butenandtstr. 5-13, D-81377 München

We present a detailed analysis of different contributions to the extrinsic spin-Hall effect on the basis of first principles calculations. As an example, we consider Cu as a host with 5*d* impurities of different concentrations. The corresponding calculations are based on the Kubo-Středa equation [1] implemented within the fully relativistic Korringa-Kohn-Rostoker (KKR) Green's function formalism in combination with the Coherent Potential Approximation (CPA) alloy theory. The decomposition of the extrinsic spin-Hall conductivity is based on the scaling behavior as suggested for the anomalous Hall effect [2]. We discuss the applicability of the latter model by comparing to the full *ab initio* description. We also analyze the results with respect to a recent model

of the extrinsic SHE in these systems [3].

[1] S. Lowitzer, D. Ködderitzsch and H. Ebert, Phys. Rev. Lett. **105**, 266604 (2010) [2] N. Nagaosa, J. Sinova, S. Onoda, A. H. MacDonald and N. P. Ong, Rev. Mod. Phys. **82**, 1539 (2010) [3] A. Fert and P. M. Levy, Phys. Rev. Lett. **106**, 157208 (2011)

MA 48.3 Fri 10:00 H23

Colossal spin Hall angle in ultrathin metallic films — •Christian Herschbach[1], Dmitry Fedorov[1], Martin Gradhand[3], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Hall, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany — [3]H. H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, United Kingdom

To use the spin Hall effect (SHE) in possible spintronics devices, materials with a large spin Hall angle (SHA) are desirable. This quantity describes the efficiency of the charge to the spin current conversion. The largest experimental value of the SHA is 24%, which was measured recently in thin film Cu(Bi) alloys by Niimi et al. [1]. The giant SHE was predicted by *ab initio* calculations of the skew-scattering mechanism in bulk Cu with substitutional Bi impurities [2]. Recently, we have extended our calculations to the film geometry and showed that the SHE can be drastically increased in monolayer noble metal films with Pt impurities in comparison to the related bulk systems [3]. In the current work we continue our study and show that with an appropriate choice of impurities in 1ML noble metal films the SHA can be as large as 80%. Such *colossal* charge to spin current conversion is very promising for spintronics applications.

[1] Y. Niimi et al., PRL **109**, 156602 (2012)
[2] M. Gradhand et al., PRL **104**, 186403 (2010)
[3] C. Herschbach et al., PRB **85** 195133 (2012)

MA 48.4 Fri 10:15 H23

Spin-Hall nano-oscillators — •Henning Ulrichs[1], Sergej Demokritov[1], Vladislav Demidov[1], Dietmar Baither[1], Guido Schmitz[1], Sergei Urazhdin[2], Vasil Tiberkevich[3], and Andrei Slavin[3] — [1]University of Muenster, Corrensstrasse 2-4, 48149 Muenster, Germany — [2]Emory University, Atlanta, GA 30322, USA — [3]Department of Physics, Oakland University, Rochester, MI, USA

Pure spin currents generated by the spin Hall effect have been recently utilized to suppress and enhance thermal magnetic fluctuations in magnetic nanodevices, and to reduce the dynamic damping in magnetic films [1].

Here, we experimentally study nano-devices driven by pure spin currents generated due to the spin Hall effect in a Pt electrode, and locally injected into an extended Permalloy film. By using micro-focus Brillouin light scattering spectroscopy, we demonstrate that above a certain current threshold, our device enters a single-mode coherent auto-oscillation regime [2]. The corresponding strongly-localized dynamic mode with the diameter below 100 nanometers, has characteristics reminiscent of the nonlinear stationary spin-wave "bullet"[3].

Our findings suggest a route for the implementation of novel magnetic nano-oscillators that have significant advantages over conventional spin-torque nano-oscillators (STNOs), whose geometry and structure are limited by the requirement that the spin current is accompanied by the electric current flowing through the ferromagnet.

1. Phys. Rev. Lett. 107, 107204 (2011), 2. Nature Materials 11, 1028 (2012), 3. Phys. Rev. Lett. 95, 237201 (2005)

MA 48.5 Fri 10:30 H23

Magnetotransport in hybrid ferromagnet/semiconductor heterostructures — •Alex Matos-Abiague and Jaroslav Fabian — Institute for Theoretical Physics, University Regensburg, 93040 Regensburg, Germany

The effects of the spin-orbit coupling (SOC) on the magnetotransport of hybrid ferromagnet/semiconductor heterostructures are discussed. In such systems the SOC fields at the ferromagnet/semiconductor interface lower the symmetry of the corresponding bulk materials. As a consequence anisotropic effects emerge in both spin and charge transport. We explore the symmetries of the SOC fields in structures with a single ferromagnetic layer and how they manifest in phenomena such as tunneling anisotropic magnetoresistance (TAMR) in magnetic tunnel junctions and anisotropic magnetoresistance (AMR) in lateral hybrid devices. Based on general symmetry considerations, we investigate how the dependence of the TAMR on the magnetization direction is determined by the specific form of the SOC field. With regard to the AMR in hybrid lateral devices we show that in addition to the usual magnetoresistance dependence on the angle between magnetization and charge current (noncrystalline AMR), a dependence on the current flow direction with respect to a reference crystallographic axis (crystalline AMR) emerges. The crystalline anisotropy of the anomalous Hall effect is also discussed.

This work was supported by the DFG (Grant No. SFB 689).

MA 48.6 Fri 10:45 H23

Anisotropy of Spin Relaxation in Metals — •Bernd Zimmermann, Phivos Maropoulos, Swantje Heers, Nguyen H. Long, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We predict a giant anisotropy of the spin relaxation time T_1, i.e. the dependence of T_1 on the orientation of the electron-spin polarization relative to the crystal lattice [1], that has not been considered so far. Our theory is based on the spin-orbit caused Elliott-Yafet (EY) mechanism, which yields the relation $T_1^{-1} \sim b^2$, where we determine the EY spin-mixing parameter b^2 and its anisotropy by *ab initio* calculations employing the Korringa-Kohn-Rostoker Green function method.

We investigate various 5d and 6sp metals and find gigantic anisotropy values for hcp-metals (up to 830% for Hf), which means that T_1 can be adjusted within one order of magnitude by changing the spin-polarization direction. We identify the formation of extended spin-flip hot areas (i.e. parts of the Fermi surface where the states are almost fully spin mixed) at nested Fermi-surface sheets or hot loops at the hexagonal face of the Brillouin zone boundary as source of the extremely high anisotropy. Our explanation is based on the spin-flip part of spin-orbit coupling in combination with the reduced symmetry of the hcp-lattice. Our findings should also be important for other effects in spintronics, e.g. the spin Hall effect. Funding by HGF (VH-NG-513) and DFG (MO 1731/3-1) is acknowledged.

[1] B. Zimmermann *et. al* , PRL in press, preprint: arXiv:1210.1801

15 min. break.

MA 48.7 Fri 11:15 H23

Spin relaxation in ultrathin metallic films: Anisotropy and surface-state effects — •Phivos Mavropoulos, Nguyen H. Long, Bernd Zimmermann, Yuriy Mokrousov, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich

We investigate the relaxation of conduction electron spins in nonmagnetic ultrathin metallic films. Within the framework of the Elliott-Yafet theory we calculate the spin-mixing parameter b^2 and the scattering matrix elements off adatoms. We show that the reduced dimensionality always leads to a significant anisotropy [1] of the relaxation rate with respect to the relative direction between the injected electron spin polarization and the crystallographic film axes. We further reveal the fundamental influence of surface states creating spin-polarization fields due to the Rashba effect. In certain cases we find unexpected even-odd effects with respect to the number of layers in the film as well as formation of spin-flip hot spots in monovalent metals. For our calculations we employ the Korringa-Kohn-Rostoker Green function method [2,3] within the local density approximation to density-functional theory. Funding from the DFG project MO 1731/3-1 is acknowledged.

[1] B. Zimmermann et al. PRL (2012, in press); arXiv:1210.1801.
[2] N. Papanikolaou, R. Zeller, and P.H. Dederichs, JPCM **14**, 2799 (2002); see also `http://www.kkr-gf.org`.
[3] S. Heers, Ph.D. Thesis, RWTH Aachen (2011); Online at:
`http://darwin.bth.rwth-aachen.de/opus3/volltexte/2011/3827`

MA 48.8 Fri 11:30 H23

Spin-polarized conductance in 1D binary alloy systems — •Ilia N. Sivkov and Valeriy S. Stepanyuk — Max Planck Institute of Microstructure Physics, Halle, Germany

Spin-dependent transmission in 1D binary alloy nanowires and contacts is studied using non-equilibrium Green's function method and density functional theory. By the example of Ni-Pt wires suspended between Pt(001) leads it is shown, that transmission through binary wires is highly dependent on the wire's geometry. The physical origin of that strong dependence and the impact of electrodes on the transmission is discussed using the local density of electronic states.

Following the paper [PRL 94, 237201], predicting a half-metal to semiconductor transition in Gd-N bulk systems, we investigate transport properties of Gd-N nanowires and compare them to 1D Gd-N

contacts. We find that infinite Gd-N zig-zag wires retain half-metallic behavior found in the bulk, which leads to a 100% spin polarization of the tunneling current. Upon stretching Gd-N wires also undergo the half-metal to insulator transition while retaining the spin-filter behavior in the whole half-metal range. To understand the importance of the interface, the infinite Gd-N nanowire is compared to a Gd-N nanowire suspended between electrodes.

MA 48.9 Fri 11:45 H23

Spin-disorder resistivity of ferromagnetic metals — •Josef Kudrnovsky[1], Vaclav Drchal[1], Ilja Turek[2], Sergei Khmelevskii[3], James Glasbrenner[4] und Kirill Belashchenko[4] — [1]Institute of Physics AS CR, Prague — [2]Charles University, Prague — [3]University of Technology, Venna — [4]University of Nebraska, Lincoln

The spin-disorder resistivity (SDR) of transition metal ferromagnets, rare-earth metals, ordered transition metal ferromagnets, and Ni-based Heusler alloys is determined from first principles. We identify the SDR at the Curie temperature with the residual resistivity of the corresponding system evaluated in the framework of the disordered local moment (DLM) model which has the zero spin-spin correlation function. The underlying electronic structure is determined in the framework of the tight-binding linear muffin-tin orbital method which employs the coherent potential approximation (CPA) to describe the DLM state. The DLM fixed-spin moment approach is used in the case when the DLM moment collapses. The Kubo-Greenwood approach is employed to estimate the resistivity. For bcc-Fe we shall also estimate the temperature-dependent of resistivity below the Curie temperature using semiempirical approach. Calculations are compared with an alternative supercell Kubo-Landauer approach developed recently as well as with available experimental data and overall good agreement is obtained.

MA 48.10 Fri 12:00 H23

Anomalous Hall effect and its anisotropy in disordered tetragonal Fe-Co alloys — •Ilja Turek[1], Josef Kudrnovsky[2], and Vaclav Drchal[2] — [1]Institute of Physics of Materials, Acad. Sci. Czech Rep., Brno, Czech Republic — [2]Institute of Physics, Acad. Sci. Czech Rep., Prague, Czech Republic

We present results of *ab initio* calculations of zero-temperature transport properties for disordered body-centered tetragonal (bct) Fe-Co alloys by using the fully relativistic TB-LMTO method, the coherent potential approximation (CPA) and the Kubo-Středa formula [1]. Particular attention has been paid to the anomalous Hall conductivity (AHC) and to the alloy composition around 60 at.% Co, for which an enhanced value of the uniaxial magnetic anisotropy energy was predicted and observed in strained Fe-Co films [2]. We have found that the AHC values for the magnetization direction pointing along the tetragonal a and c axes can differ nearly three times for certain tetragonal distortions and alloy compositions. This anisotropy exceeds that calculated for pure tetragonal Fe and Co metals and it seems to be surprisingly stable with respect to the alloy disorder. Further aspects of the predicted behavior including its possible experimental verification will also be briefly discussed. [1] I. Turek et al., Phys. Rev. B 86, 014405 (2012). [2] I. Turek et al., arXiv:1210.1028 (2012).

MA 48.11 Fri 12:15 H23

Exploiting spin extraction for local spin valve structures — •Yori Manzke, Rouin Farshchi, Pawel Bruski, Jens Herfort, and Manfred Ramsteiner — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

We show that spin extraction [1] can serve as the spin generation mechanism in local spin valves. In contrast to electrical spin injection, which is commonly employed in such magnetoresistance devices, spin accumulation in a non-magnetic semiconductor (SC) is created upon an electron flow from the SC into a ferromagnetic metal Schottky contact. The investigated samples comprise ferromagnetic Heusler alloy (Co_2FeSi) contact stripes on an n-type GaAs channel. A current divider arrangement is used to generate spin polarized drift currents by spin extraction and to sense spin-induced changes in contact resistance at a subsequent ferromagnetic stripe. We discuss the extension of this scheme to spin valves based on multiple extraction events. Generally, the electrical output signal of our magnetoresistance devices depends on the relative orientation of the contact magnetizations and we obtain 2^{m-1} electrical output states for m ferromagnetic contacts. Our results suggest that multiple spin extraction may find its application in the generation of highly spin-polarized drift currents and as a read-out mechanism in magnetic data storage. This work was partially supported by the DFG via SPP 1538.

[1] J. Stephens *et al.*, Phys. Rev. Lett. **93**, 097602 (2004).

MA 48.12 Fri 12:30 H23

Spin Accumulation in transition Metal thin Films from First Principles — •Frank Freimuth, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We present first-principles calculations of the spin accumulation in paramagnetic transition metal thin films due to applied in-plane electric fields. Two contributions to the spin accumulation are identified: The first contribution is the accumulated spin current from the spin Hall effect and depends on the spin diffusion length. The second contribution arises from the surface Rashba and the bulk Rashba effects. It is not directly related to the spin current flowing towards the surfaces and independent of the spin diffusion length. The spatial distributions of spin accumulation and spin current are also discussed and compared to model predictions. Furthermore, we discuss spin accumulation and resulting torques in thin ferromagnetic layers stacked on top of paramagnetic layers. This work is supported by the HGF-YIG grant VH-NG-513.

MA 49: Magnetization Dynamics III of 3

Time: Friday 9:30–12:00 Location: H22

MA 49.1 Fri 9:30 H22

Driving magnetization dynamics via mid-infrared phonon excitation — •Sebastian Mährlein[1], Ilie Radu[2], Michael Gensch[3], Alexey Kimel[4], Alexandra Kalashnikova[5], Roman Pisarev[5], Martin Wolf[1], and Tobias Kampfrath[1] — [1]Fritz Haber Institute of the Max Planck Society, 14195 Berlin, Germany — [2]Helmholtz-Zentrum Berlin BESSY II, 12489 Berlin, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany — [4]Radboud University Nijmegen, Nijmegen 6525AJ, The Netherlands — [5]A.F. Ioffe Physical Technical Institute, St. Petersburg 194021, Russia

The fundamental interactions between electrons, spins and the lattice of a solid have always been subject of large scientific interest. Here, we investigate the coupling between phonons and the ordered spin system of ferrimagnetic oxides on ultrashort time scales, an elusive and actively debated issue of modern ultrafast magnetism.

For this purpose, we use intense electromagnetic pulses at terahertz (THz) frequencies, from both table-top and accelerator-based sources, to resonantly excite a specific phonon mode. The impact of this vibrational excitation on the spin system is monitored by detecting the transient Faraday rotation of a subsequently arriving optical probe pulse. As such, we obtain access to the magnetization dynamics with a time resolution of down to 10fs. These mode-selective pumping experiments show a response of the spin system on a timescale of few picoseconds and thus indicate an (ultra)fast spin-lattice interaction. The possible underlying coupling mechanisms will be discussed.

MA 49.2 Fri 9:45 H22

The ultrafast demagnetization-time and -rate of Ni after laser pulse irradiation within the Elliott-Yafet theory — •Christian Illg, Michael Haag, and Manfred Fähnle — Max-Planck-Institut für Intelligente Systeme, Heisenbergstr. 3, 70569 Stuttgart, Germany

It is well known that a thin Ni film demagnetizes within about 100 fs after irradiation with a strong fs laser pulse [1]. Several mechanisms have been proposed which try to explain this effect but until now the underlying mechanism is still unclear [2].

We use the Elliott-Yafet theory which has the electron-phonon scattering as underlying mechanism and which we have extended to ferromagnets [3]. We calculate the demagnetization-time and -rate in Ni by

using the ab-initio spin-density-functional theory (realistic electronic states) and an ab-initio force-constant model [4] (realistic phonon states). Finally, we compare the results with experimental data for low laser fluences.

Furthermore, the total angular momentum conservation during the demagnetization process is discussed thoroughly.

[1] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250 (1996)
[2] M. Fähnle, C. Illg, J. Phys.: Condens. Matter 23, 493201 (2011)
[3] D. Steiauf, C. Illg, M. Fähnle, J. Magn. Magn. Mater. 322, L5 (2010)
[4] C. Illg, B. Meyer, M. Fähnle, Phys. Rev. B 86, 174309 (2012)

MA 49.3 Fri 10:00 H22

Left-right symmetry breaking of spin wave propagation in magnetic tubes — •Attila Kákay[1], Ming Yan[2], and Riccardo Hertel[3] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Deutschland — [2]Shanghai University, Shanghai, China — [3]IPCMS, CNRS UMR 7504, Strasbourg, France

A recent micromagnetic study [1] predicted chiral symmetry breaking of domain wall (DW) dynamics in magnetic nanotubes. This striking behavior arises from the curvature of the magnetic surface. In this investigation based on our micromagnetic finite-element code TetraMag [2], we show that the curvature of the tube surface does not only affect the DW motion, but has also a significant effect on the spin wave propagation. We observe a left-right symmetry break in the propagation of Damon-Eshbach type spin waves. The waves are excited by applying locally a monochromatic high-frequency magnetic field. We find that in tubular geometries with purely azimuthal magnetization, spin waves with the same frequency, surprisingly, display different wavelengths when propagating to the left or to the right. Therefore, the magnon dispersion relation of magnetic tubes does not only depend on the wave number, but also on its sign. Our systematic micromagnetic analysis shows that this effect is scale-invariant and that it originates from the magnetostatic interaction. We conclude that this is a general property of ferromagnetic curved surfaces and tubes.

[1] M. Yan, C. Andreas, A. Kákay, F. Garcia-Sanchez and R. Hertel, *Appl. Phys. Lett.* **100** 252401 (2012) [2] A. Kákay, E. Westphal and R. Hertel, *IEEE Trans. Magn.* **46** 2303 (2010)

MA 49.4 Fri 10:15 H22

Elastically driven ferromagnetic resonance in nickel thin films — •Matthias Pernpeintner[1], M. Weiler[1], L. Dreher[2], H. Huebl[1], R. Gross[1], M. S. Brandt[2], and S. T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany

Recently, it has been shown that elastic strain induced by coherent phonons in a ferromagnet can be used to resonantly excite magnetization precession via magnetoelastic coupling [1,2]. In our experiments, we study hybrid structures consisting of a bulk $LiNbO_3$ crystal covered by a thin nickel film. A surface acoustic wave (SAW) propagating on the $LiNbO_3$ surface induces coherent phonons in the Ni film. The resulting magnetization dynamics are studied as a function of orientation and strength of an externally applied, static magnetic field. We present an analytical model as well as numerical calculations which quantitatively reproduce our experimental results. Furthermore, we analyse the effects of the SAW type on the magnetization dynamics. We also present recent experimental data obtained from a $LiTaO_3$/Ni hybrid structure, which supports both Rayleigh and shear-horizontal waves. Our results open the path for radio-frequency magnon-phonon coupling experiments, e.g., acoustic spin pumping. Financial support from the DFG via SPP 1538 SpinCAT and the Excellence Cluster Nanosystems Initiative Munich (NIM) is gratefully acknowledged.

[1] M. Weiler *et al.*, Phys. Rev. Lett. **106**, 117601 (2011)
[2] L. Dreher *et al.*, Phys. Rev. B **86**, 134415 (2012)

MA 49.5 Fri 10:30 H22

Configurational dependence of the magnetization dynamics in spin valve systems — •Ruslan Salikhov[1], Radu Abrudan[1], Frank Brüssing[1], Florin Radu[2], Ilgiz Garifullin[3], Kurt Westerholt[1], and Hartmut Zabel[1] — [1]Ruhr-Universität Bochum, Germany — [2]Helmholtz Zentrum Berlin für Materialien und Energien, Berlin, Germany — [3]Zavoisky Physical-Technical Institute of Russian Academy of Sciences, Kazan, Russia

Using time-resolved x-ray resonant magnetic scattering (tr-XRMS), which was implemented using the ALICE chamber at BESSY II of the Helmholtz Zentrum Berlin [1], we report on the precessional dynamics of spin valve systems with parallel (P) and antiparallel (AP) orientation of magnetizations. We observe in Co/Cu/Py spin valve systems an increase of the magnetic damping parameter in Py with changing magnetization direction of Py and Co layers from P to AP orientation [2]. We attribute this finding to the configurational dependence of the spin pumping effect [3]. Furthermore we studied the temperature dependence and possible other causes for the configurational dependence of the damping parameter, such as domain wall induced coupling or magnetic dipole coupling [4]. The main focus is on Co/Cu/Py trilayers and on Co2MnGe/V/Py trilayers with spin valve properties.

[1] St. Buschhorn et al., J. Synchr. Rad. 18, 212 (2011). [2] R. Salikhov et al., Appl. Phys. Lett. 99, 092509 (2011). [3] J.-V. Kim, C. Chappert, JMMM 286, 56 (2005). [4] R. Salikhov et al., Phys. Rev. B 86, 144422 (2012).

MA 49.6 Fri 10:45 H22

A new resonance in vortex core switching based on an interaction between gyromode and spin-waves — •Markus Sproll[1], Hans Bauer[2], Matthias Kammerer[1], Matthias Noske[1], Georg Dieterle[1], Ajay Gangwar[2], Markus Weigand[1], Hermann Stoll[1], Georg Woltersdorf[2], Christian Back[2], and Gisela Schütz[1] — [1]MPI for Intelligent Systems, Stuttgart, Germany — [2]Department for Experimental Physics, University of Regensburg, Germany

The discovery of low-field vortex core (VC) switching using the sub-GHz vortex gyromode [1] as well as the much faster VC reversal by excitation of magnetostatic azimuthal spin waves in the multi-GHz range [2] mark milestones in the chapter of non-linear magnetic VC dynamics and finally lead to switching times within less than 100 ps. Here we report on surprising and unexpected new effects which have been observed by experiments at the MAXYMUS x-ray microscope at BESSY II, when the linear (sub-GHz) gyromode and circular (multi-GHz) spin waves are excited simultaneously. (i) A lowering of up to one order of magnitude of the spin wave mediated VC switching threshold is found with increasing gyromode excitation, explained by an interference of the spin waves with the excited gyromode rotation and (ii) a new additional resonance at 2.5 GHz appears which is explained by frequency doubling leading to a generation of the 'regular' 5 GHz (n=1, m=-1) spin wave mode - but only, if the sub-GHz gyromode is excited simultaneously. [1] Van Waeyenberge et al., Nature 444, 461 (2006); [2] Kammerer et al., Nature Communications 2, 279 (2011)

MA 49.7 Fri 11:00 H22

Spin wave mediated sub-100 ps vortex core reversal — •M. Noske[1], M. Weigand[1], M. Kammerer[1], M. Sproll[1], G. Dieterle[1], A. Gangwar[3], B. Van Waeyenberge[2], H. Stoll[1], G. Woltersdorf[3], C. Back[3], and G. Schütz[1] — [1]MPI for Intelligent Systems, Stuttgart — [2]Department of Solid State Science, Ghent University, Belgium — [3]Department of Physics, Regensburg University

Low field magnetic vortex core (VC) reversal by exciting the sub-GHz vortex gyromode [1] has triggered intensive studies of VC dynamics, also due to its potential for spintronics applications. Recently we could speed up VC switching significantly by exciting magnetostatic azimuthal spin wave modes with rotating multi-GHz ac magnetic field bursts [2,3]. In this contribution we demonstrate VC switching times below 100 ps and unidirectional VC reversal in sub-micron Permalloy discs by excitation with two orthogonal unipolar magnetic field pulses of 50 ps. The magnetization dynamics during VC reversal were imaged by time-resolved scanning transmission X-ray microscopy at the MAXYMUS endstation at BESSY II with time and spatial resolution of 45 ps and 25 nm. Phase diagrams for VC reversal were obtained by varying lengths, amplitudes and the sense of rotation of the pulse sequence revealing a small parameter range for selective VC reversal. All our results are in good agreement with micromagnetic simulations.

[1] B. Van Waeyenberge et al., Nature 444, 461-464 (2006).
[2] M. Kammerer et al., Nature Communications 2, 279 (2011).
[3] M. Kammerer et al., PRB 86, 134426 (2012).

MA 49.8 Fri 11:15 H22

Spin waves in a microstructured metallic magnonic crystal with periodic variation of the saturation magnetization — •Björn Obry[1], Thomas Brächer[1,2], Philipp Pirro[1], Andrii V. Chumak[1], Florin Ciubotaru[1], Alexander A. Serga[1], Julia Osten[3], Jürgen Fassbender[3], and Burkard Hillebrands[1] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, 67663 Kaiserslautern, Germany — [3]Institut für Io-

nenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany, and TU Dresden, 01062 Dresden, Germany

We study spin waves in a microstructured magnonic crystal consisting of a $Ni_{81}Fe_{19}$ (Permalloy) waveguide with a periodic variation of the saturation magnetization M_S. By localized ion implantation of the waveguide a modification of the saturation magnetization to $M_S/M_S^0 = 0.93$ has been obtained. Brillouin light scattering microscopy measurements of the spin-wave propagation spectrum yield two pronounced band gaps, where spin-wave propagation is prohibited. Two cases of the spin-wave excitation inside and outside the magnonic crystal region are presented. Due to the narrow band gaps achieved by the absence of topographical structuring and due to the existence of nonlinear multi-magnon interactions this magnonic crystal allows for a deeper insight into the general wave dynamics in metamaterials.

MA 49.9 Fri 11:30 H22

Nonreciprocal spin waves excitation in perpendicular magnetized Permalloy microstructures — •Florin Ciubotaru, Alexander Serga, Andrii Chumak, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Spin waves in micro- and nanosized magnetic structures have attracted growing attention due to the prospective applications in magnon spintronic devices. For example, the use of phase and amplitude of spin waves as an information carrier in magnetic logic circuits is extensively studied. The control of spin-wave excitation and the manipulation of their propagation characteristics is of crucial importance for the development of such devices. Here we report on micromagnetic simulations [1] of the spin-wave emission from a nanosized antenna in perpendicular magnetized Permalloy microstructures. We show that depending on the film thickness the same antenna exhibit either a symmetric or an asymmetric spin-wave radiation. In addition, the character of the spin-wave emission can be controlled by the excitation frequency at a fixed bias magnetic field. Support from DFG (grant SE-1771/1-2) is gratefully acknowledged. [1] OOMMF open code, M. J. Donahue, and D. G. Porter, Report NISTIR 6376, NIST, Gaithersburg, MD (1999).

MA 49.10 Fri 11:45 H22

Effects of the lattice discreteness on the Damon-Eshbach mode — •Julian Hüser, Thomas Kendziorczyk, and Tilmann Kuhn — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Spin wave dispersion relations in ferromagnetic thin films are often calculated within a continuum model based on the Landau-Lifshitz equation thereby neglecting the underlying lattice structure in real materials. In this talk we present and analyze some differences between the magnetostatic modes obtained in a lattice model and the well known results of Damon and Eshbach. For this purpose we calculate the spin wave dispersion with a discrete model consisting of classical spins which are stacked on a cubic lattice and interact only via dipolar forces. The discrete model yields new qualitative features in comparison with the results of Damon and Eshbach. We observe several surface modes and the degeneracy of the spin waves which propagate perpendicularly to the applied magnetic field is lifted. These modes form a quasi-continuous volume band in which hybridizations between the modes take place.

MA 50: Poster II

Magnetic Measurement Methods, Magnetic Thin Films,Micro- and Nanostructured Materials, Magnetization Dynamics,Computational Magnetism,Spin-dependent Transport Phenomena,Spincaloric Transport, Spin-Injection and - Currents in Heterostructures,Spintronics

Time: Friday 10:30–13:30 Location: Poster D

MA 50.1 Fri 10:30 Poster D

Nanoscale sensing of a magnetic topology — •Alexander Gerstmayr[1], Raphael Bindel[2], Dominik Reitzle[3], Marcus Liebmann[2], Markus Morgenstern[2], Berndt Koslowski[3], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Universität Ulm, Deutschland — [2]Institut IIb, RWTH Aachen, Deutschland — [3]Festkörperphysik, Universität Ulm, Deutschland

For years, the nitrogen-vacancy (NV) center in diamond has been in the spotlight for studies of electron spin coupling. Also the coupling to other near 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). For even higher magnetic sensitivity (down to few nT of AC field), pulsed experiments are performed. 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 in NV-centers under ambient conditions, this combination of AFM and MRM is planned to work even at room temperature as well as also at low temperature (4 K). We will be able to locate single spins on the nanoscale.

MA 50.2 Fri 10:30 Poster D

Exploring the magnetization dynamics and interaction effects of single microparticles with Hall-magnetometry — •Martin Lonsky[1], Merlin Pohlit[1], Sven Heinz[1], Pintu Das[1], Natalija van Well[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

Micro-Hall-magnetometry is a powerful technique for studying the magnetization dynamics of micrometer- and nanometer-scale particles. Our sensors are based on the two-dimensional electron gas in GaAs/AlGaAs heterostructures and allow for magnetic stray-field measurements of *individual* micron-sized particles positioned on one or several lithographically defined Hall crosses. Besides the standard experiment of measuring magnetization switching in ferromagnets, we extend the fields of application of this technique to susceptibility and static and dynamic magnetic flux measurements. In order to further optimize the compatibility with standard fabrication methods of nanotechnology we aim to establish planar contact geometries as opposed to In/Sn soldered contacts. We recently demonstrated the high resolution of our devices by tracking the domain wall dynamics in a single CrO_2 micro-grain that has been positioned with a micromanipulator [1]. A further step will be to study interaction effects between individual grains and the influence of intrinsic and extrinsic pinning on the domain wall dynamics.
[1] P. Das et al., APL 97, 042507 (2010).

MA 50.3 Fri 10:30 Poster D

Magnetometry on the nanometer scale using nanogranular tunnel resistors prepared by focused electron-beam-induced deposition — •Peter Gruszka, Marcel Winhold, Christian H. Schwalb, and Michael Huth — Physikalisches Institut, Goethe-Universität, Max-von-Laue-Str.1, 60438 Frankfurt am Main

By using conventional methods of magnetometry one can experience difficulties when having small amounts of sample materials. Our novel approach uses focused electron-beam-induced deposition (FEBID) for the realization of small magnetic structures using the precursor $Co_2(CO)_8$ (Dicobaltoctacarbonyl). The magnetic structures are deposited on thin cantilever structures that are equipped with nanogranular tunnel resistors (NTRs) at the bending edge of the cantilever also prepared by FEBID.[1] Applying an external magnetic field to the cantilever induces a magnetic torque resulting in a deflection of the cantilever that can be measured due to a resistance change of the NTR sensor elements. The all-electric measurement enables us to measure precisely the temperature dependent magnetic properties of sample volumes as small as $1\mu m^3$.
[1] Schwalb et al., Sensors 2010, 10, 9847-9856

MA 50.4 Fri 10:30 Poster D

Treshold magnetic circular dichroism as a contrast mechanism for imaging magnetization dynamics of thin films — •Maximilian Staab, Hans-Joachim Elmers, Mathias Kläui, and Gerd Schönhense — Johannes Gutenberg-Universität, 55099 Mainz, Germany

Investigations of thin magnetic films like Co/Pt or Co/Au promise novel findings to overcome existing limits of data storage devices. Threshold magnetic circular dichroism (MCD) in photoemission is a phenomenon which allows gathering information about the details of the electronic structure near E_F [1]. Photons generated from a femtosecond laser excite electrons at the magnetic surface and eject them from the material. The yield of electrons is directly influenced by the relative orientation of the magnetization direction of the surface layer and the helicity of the incoming photons. By changing the helicity one obtains yield asymmetries of the order of 10% and more, making threshold MCD a great contrast mechanism for imaging dynamical processes in magnetic materials.

The combination of photoemission electron microscopy with MCD sensitivity and a femtosecond laser setup is capable of investigating magnetization dynamics with great spatial and time resolution. The process of ultrafast demagnetization and the current-induced domain wall motion by spin torque transfer are two very interesting phenomena which will be explored.

Project funded by DFG EL172/15.

[1] K. Hild et al., Phys. Rev. B 82, 195430 (2010)

MA 50.5 Fri 10:30 Poster D

Manipulating the Heat Conductivity of $La_{0.67}Ca_{0.33}MnO_3$ using External Magnetic Fields — •Christoph Euler, Christian Mix, Tino Jäger, Ramudu Machavarapu, Mathias Kläui, and Gerhard Jakob — University of Mainz, Germany

Recently research has been conducted on the interaction between electron spin and heat conduction. It was shown that heat currents can generate spin currents in magnetic nanostructures, which in turn can manipulate the magnetization [1]. Such spin-caloric mechanisms are frequently studied in thin films.

$La_{0.67}Ca_{0.33}MnO_3$ (LCMO) is a doped manganese oxide displaying huge magnetoresistivity (CMR)[2]. LCMO is a paramagnetic insulator above $T_C \approx 230\,\mathrm{K}$ and ferromagnetic and semiconducting below. LCMO films ($d \approx 200\,\mathrm{nm}$) are deposited on $SrTiO_3$ substrates using pulsed laser deposition in an O_2 atmosphere. The samples are characterized using XRD, AFM and VSM. A 3ω method is then used to determine the out-of-plane thermal conductivity.

The transport properties of LCMO have been studied previously [3]. In a material displaying CMR, by virtue of the Wiedemann-Franz law it should also be possible to modify the heat conductivity of a sample by applying external magnetic fields in a low-temperature magnetic cryostat. First results of the thermal conductivity are presented.

[1] K. Uchida et al., Nature 455, 778 (2008).
[2] R. von Helmolt et al., Phys. Rev. Lett. 71 (1993) 2331.
[3] G. Jakob et al., Phys. Rev. B58 (1998) 14966.

MA 50.6 Fri 10:30 Poster D

Effects of mechanical stress to GMR/TMR elements — •Stefan Niehörster, Andy Thomas, and Günter Reiss — Universität Bielefeld, Germany

By applying a mechanical stress to thin film giant magnetoresistance (GMR) and tunnel magnetoresistance (TMR) elements, it is possible to influence their resistive behavior because of the inverse magnetostriction. Dependent on the direction between the applied mechanical stress and the magnetic field, it is possible to increase/decrease the GMR/TMR ratio and to influence the shape of their hysteresis. With the applied stress perpendicular to the magnetic field, the TMR ratio decreased from 192% to 151%. A parallel stress increased the TMR ratio from 193% to 208%. In this case, the applied stress was just limited by the mechanical breakdown of the wafer. Otherwise, the changes in the ratios and the shape of the hysteresis were reversible.

MA 50.7 Fri 10:30 Poster D

Development of a maganite-film-based AMR sensor for low magnetic fields using the planar Hall effect — •Camillo Ballani, Sebastian Hühn, Markus Jungbauer, Markus Michelmann, and Vasily Moshnyaga — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The anisotropic magnetoresistance (AMR) is widely used for sensing of both direction and absolute value of magnetic fields. Besides conventionally used ferromagnetic metallic materials, like permalloy ($Ni_{80}Fe_{20}$), thin epitaxial manganite films, e.g. $La_{0.7}(Sr_{1-y}Ca_y)_{0.3}MnO_3$, show large AMR ratios at temperatures slightly below T_C, which can be tuned close to room temperature by changing the Sr/Ca ratio.[1] For a special AMR geometry, called "planar Hall effect", the measured transverse voltage is directly proportional to the sample magnetization, M, thus allowing one to obtain very high field sensitivity at low fields $H \lesssim H_C$. With the goal to achieve low H_C and high AMR ratios, we have grown thin manganite films on $SrTiO_3$ substrates with different orientations by metalorganic aerosol deposition technique and studied the dependence of planar Hall effect on the temperature and applied magnetic field. Using the optimized films, we developed a prototype of a manganite-film-based magnetic field sensor. Financial support from EU FP 7 Project IFOX (interfacing oxides) is acknowledged.

[1] J. Appl. Phys. 93, 6354 (2003)

MA 50.8 Fri 10:30 Poster D

Magnetic and transport properties of MnSi thin films — •Josefin Engelke[1], Niklas van Elten[1], Tommy Reimann[1,2], Dirk Menzel[1], and Stefan Süllow[1] — [1]Inst. für Physik d. Kond. Materie, TU Braunschweig, Germany — [2]Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II), TU München, Germany

The ferromagnetic compound MnSi has recently aroused great interest since a variety of different phases is observed in the magnetic phase diagram. Besides a helical spin structure a topologically stable skyrmion phase occurs in a small temperature region close to the ordering temperature. By reducing the dimensionality from bulk to thin films it is expected that the skyrmions are present over a larger temperature regime. Using molecular beam epitaxy we have grown MnSi thin films by simultaneous deposition of Mn and Si. Magnetization and magnetoresistivity measurements have been carried out and related to the magnetic phase diagram. We observe a thickness dependence of the ordering temperature, which can be explained by the reduction of spin-spin interactions in the vicinity of the film surface. In comparison to bulk MnSi critical magnetic fields are enhanced, which is interpreted in terms of the reorientation of the helix affected by the film anisotropy.

MA 50.9 Fri 10:30 Poster D

Towards novel functionality with metal and complex oxide thin films prepared with molecular beam epitaxy — •Alexander Weber[1], Markus Waschk[1], Alexandra Steffen[2], Sabine Pütter[2], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS-2 und Peter Grünberg Institut PGI-4: Streumethoden, Forschungszentrum Jülich GmbH — [2]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Außenstelle am FRM II, Garching

At the Jülich Centre for Neutron Science two state of the art Oxide Molecular Beam Epitaxy systems were commissioned in 2010. Up to now we managed to produce thin metal and oxide films in single layers as well as multilayers, like Fe/Cr, LaSrMnO3 a.s.f. with high crystalline quality and very low roughness. Here we present the results on LaMnO3/SrMnO3 (LMO/SMO) multilayers grown on SrTiO3 with inter layer roughness of one mono layer. The multilayers show an interface induced ferromagnetic behavior within the LMO in contrast to the antiferromagnetic behavior of the single layers. The structural analysis concerning layer thickness and unit cell size was done with X-ray reflectometry and X-ray diffraction. We carried out a thickness dependent study of the magnetic moment induced by the interfaces with SQUID magnetometry. Here we observed a raise in the net magnetic moment of the LMO with decreasing layer thickness. To study the depth resolved magnetization profile within the LMO we measured several multilayers with varying layer thickness on D17 at the ILL. The results fit well to our simple model for the magnetic profile.

MA 50.10 Fri 10:30 Poster D

Conical Spin-Spiral State in an Ultrathin Film — •N. Romming[1], Y. Yoshida[1], S. Schröder[2], P. Ferriani[2], D. Serrate[1], A. Kubetzka[1], K. von Bergmann[1], S. Heinze[2], and R. Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, D-20355 Hamburg, Germany — [2]Institute for Theoretical Physics and Astrophysics, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany

We report a transverse conical spin spiral as the magnetic ground state of a double-layer Mn on a W(110) surface. Using spin-polarized scanning tunnelling microscopy, we find a long-range modulation along the

[001] direction with a periodicity of 2.4 nm coexisting with a local row-wise antiferromagnetic contrast. First-principles calculations reveal a transverse conical spin-spiral ground state of this system which explains the observed magnetic contrast. The canting of the spins is induced by higher-order exchange interactions, while the spiralling along the [001] direction is due to frustrated Heisenberg exchange and Dzyaloshinskii-Moriya interaction. In addition, we show how the spin spiral's cone angle can be determined experimentally and how this sample can be used as a reference system to fully characterize the spin direction of SP-STM tips.

MA 50.11 Fri 10:30 Poster D

Growth of thin $La_{0.7}Sr_{0.3}MnO_3$ films on $SrTiO_3$ substrates with different orientations — •Danny Schwarzbach, Markus Jungbauer, Sebastian Hühn, Markus Michelmann, and Vasily Moshnyaga — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Thin film peculiarities like oxygen vacancies, epitaxial strain, orbital reconstruction at the interface and especially the polar catastrophe are of great interest for the physics and technology of correlated oxide films. We studied the growth and preparation of epitaxial films of $La_{0.7}Sr_{0.3}MnO_3$ with a thickness $d = 5-120$ nm on $SrTiO_3$ substrates with (100), (110) and (111) orientations, to get more insight on the above effects.

All films were found to be coherently strained and show qualitatively similar ferromagnetic and metallic behaviour. However, the orientation of substrates influences significantly the values of Curie point T_C, metal-to-insulator transition temperature T_{MI}, coercive field H_C and magnetic anisotropy.

Especially the (111) films show the highest T_C and T_{MI} as well as the lowest H_C. For example, the film with $d = 30$ nm reveals $T_C = 362$ K and $H_C(5\text{ K})$ less than 2 - 5 Oe, which indicates practically the absence of magnetic anisotropy. The results are discussed within the orbital reconstruction and polar catastrophe, which both depend on the crystal orientations.

Support of EU Seventh Framework Programme via IFOX is acknowledged.

MA 50.12 Fri 10:30 Poster D

Exchange bias in DyCo/NiFe bilayer — •Kai Chen[1], Dieter Lott[1], Andreas Schreyer[1], R.S Iskhakov[2,3], S.V Stolyar[2,3], and V.Yu Yakovchuk[2] — [1]Institute for Materials Research, Helmholtz-Zentrum Geesthacht, 21502 Geesthacht , Germany — [2]Kirensky Institute of Physics SB RAS, Krasnoyarsk, 660036,Russia — [3]Siberian Federal University, Krasnoyarsk, 660041, Russia

High in-plane exchange bias up to 40 mT at room temperature was found through-out the whole hard ferrimagnetic layer of DyCo which is coupled to NiFe layer. The exchange bias effects can be achieved here by magnetizing the DyCo in perpendicu-lar direction in respect to the film plane. The direction of the shifts of the in-plane hysteresis is dependent on the direction of the pre-magnetization in the one or other direction. Results from magnetic optical Kerr effect (MOKE), X-ray magnetic cir-cular dichorism (XMCD) and Polarized Neutron Reflectometry (PNR) are discussed to investigate the mechanism behind.

MA 50.13 Fri 10:30 Poster D

Magnetization reversal analysis of thin magnetic films studied by magnetooptic Kerr effect including superimposed uniaxial and cubic magnetic anisotropy — •Timo Kuschel[1], Jaroslav Hamrle[2], Jaromir Pistora[2], Kesami Saito[3], Subrojati Bosu[3], Yuya Sakuraba[3], Koki Takanashi[3], Henrik Wilkens[4], and Joachim Wollschläger[4] — [1]University of Bielefeld, Germany — [2]Technical University of Ostrava, Czech Republic — [3]Tohoku University of Sendai, Japan — [4]University of Osnabrück, Germany

Fe and $Co_{50}Fe_{50}$ films on MgO(001) are investigated by vectorial magnetometry via magnetooptic Kerr effect (MOKE). Measurements using s- and p-polarized incident light and an external magnetic field either parallel or perpendicular to the incidence plane of light are performed. Additionally, different in-plane orientations of the crystalline samples with respect to the external magnetic field are analyzed.

The observed magnetic reversal processes reveal two in-plane magnetic easy axes (MEAs) of different strength which are not orthogonal. Atypical magnetization curves including multidomain states with some magnetic moments providing antiparallel alignment to the external field (if projected to the direction of the external field) confirm the appearance of differently strong MEAs. This magnetic structure can be explained by a cubic magnetic anisotropy (CMA) induced by the crystalline film structure superimposed by an additional uniaxial magnetic anisotropy (UMA) which is not parallel to one of the MEAs of the CMA. The results are compared with regular magnetic films having a UMA parallel to one of the MEAs of the CMA.

MA 50.14 Fri 10:30 Poster D

Raman spectroscopy on thin manganite films — •Sebastian Merten[1], Sebastian Hühn[1], Antje Krüger[1], Christin Kalkert[1], Burkhard Schmidt[2], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Abteilung Mineralogie, Geowissenschaftliches Zentrum, Georg-August-Universität Göttingen, Goldschmidtstraße 1, 37077 Göttingen, Germany

A commonly believed picture is the colossal magnetoresistance effect in thin manganite films is related to a first order magnetic phase transition which can be also coupled to a structural phase transition from an orthorhombic (Pnma) to a rhombohedral ($R\bar{3}c$) structure. This structural change can be reflected in Raman spectra which provide information of the phonon modes specific to the structural phases involved. Here we report on the Raman spectroscopy of epitaxial manganite films of $La_{0.7}Sr_{0.3}MnO_3$, $La_{0.7}Ca_{0.3}MnO_3$ and $(La_{65}Pr_{45})_{0.7}Ca_{0.3}MnO_3$ grown on MgO (100)-substrates. We observed the known Raman peaks characteristic for both structures as was identified in previous works. Moreover, the details of the phase transition and phase competition could be obtained from the temperature behaviour of the Raman peaks. In addition first results of Surface-enhanced Raman spectroscopy (SERS) will be presented on $La_{0.7}Ca_{0.3}MnO_3$. We covered the surface of the films with commercially available gold nanoparticles with the dimensions of 25x60 nm and detected an enhancement of 2-3 orders of magnitude. SFB 602(TPA2) is acknowledged.

MA 50.15 Fri 10:30 Poster D

Magnetocaloric effect in layered thin film Heusler-type materials — •Anna Möhn[1,2], Anja Waske[1], Niclas Teichert[3], Andreas Hütten[3], and Jürgen Eckert[1,4] — [1]IFW Dresden, Institute for Complex Materials, Dresden, Germany — [2]TU Dresden, Institut für Festkörperphysik, Dresden, Germany — [3]Universität Bielefeld, Fakultät für Physik, Bielefeld, Germany — [4]TU Dresden, Institut für Werkstoffwissenschaft, Dresden, Germany

The magnetocaloric effect (MCE) is the increase of temperature of a material upon the application of a magnetic field and decrease when it is removed [1]. Materials which exhibit a giant MCE have a strong coupling between crystallographic structure and magnetism [2]. However, the abrupt structural change that is the origin of "giant" magnetocaloric effects, also leads to significant strain occuring in the material. The effect of strain on the magnetocaloric performance is yet unclear. To systematically study the influence of strain, we investigate a bilayer model system which introduces strain by a lattice mismatch at the interface of two different magnetocaloric materials. Experimentally we investigated sputtered thin film samples of different NiMnGa, NiMnSn and NiCoMnSn composition which show regular and inverse MCE, respectively. We determined the magnetic properties of the thin films as a function of temperature and applied magnetic field. Furthermore we determined the magnetic properties of multilayered samples which are consist of different NiMnGa and NiMnSn alloys.

[1] Giauque et. al., Phys. Rev., 43, 768 (1933)
[2] Liu et. al., Nature Mater., 11, 620 (2012)

MA 50.16 Fri 10:30 Poster D

Magnetic Properties of the Fe-GaAs(110) Interface with ultrathin films investigated by In-Situ MOKE Measurements — Tim Iffländer, Martin Wenderoth, •Steffen Rolf-Pissarczyk, Steffen Weikert, Lars Winking, and Rainer G. Ulbrich — IV. Phys. Inst., Georg-August-Universität Göttingen

We have investigated the magnetic properties of ultrathin Fe Films epitaxially grown on the GaAs(110) and the InAs(110) surface. The films were deposited in a two-step process at 130 K to avoid any interface mixing. In-situ STM and LEED measurements proved an abrupt interface and an epitaxial growth of the Fe-GaAs system. In-situ magneto-optical kerr effect (MOKE) measurements at RT were conducted for different longitudinal, transversal and polar orientations of the applied magnetic field with respect to the (110) surface of the GaAs sample. For the 2-3 ML thickness regime deposited at low-temperature an interchange of the easy-axis from the [110] to the [001]-axis was in contrast to at RT grown Fe films observed. Moreover, we found a

magnetic anisotropy along the [001]-axis which is connected to a polar magnetization component.

In addition, several MOKE hysteresis loops for different magnetic field directions and a fixed laser beam were taken to distinguish easy-axis from hard-axis behaviour. Hence we were able to show that in comparison to the in-plane [001]-axis the out-of plane direction is not a magnetic easy-axis. These results indicate a strong spin-orbit coupling in these compount systems. This work was supported by the Deutsche Forschungsgemeinschaft SFB 602 TP A7 and SPP 1285.

MA 50.17 Fri 10:30 Poster D

Domain formation in laminated FeCoBSi films for ME sensor applications — •Necdet Onur Urs[1], Christine Kirchhof[1], Dirk Meyners[1], Robert Jahns[2], Eckhard Quandt[1], Reinhard Knöchel[2], and Jeffrey McCord[1] — [1]Institute for Materials Science, Kiel University, Germany — [2]Institute of Electrical and Information Engineering, Kiel University, Germany

Magnetic domain activities in magnetoelectric (ME) sensors severely limit the sensor sensitivity, which can be solved by laminating the magnetic layers with non-magnetic materials. Magnetron-sputtered FeCoBSi/Ta multilayer thin films of different thicknesses and their single layer counterparts with the same total thickness are investigated by magneto-optical Kerr microscopy. All samples are annealed under a magnetic field to obtain a well defined uniaxial anisotropy. The domain structure changes depending on the FeCoBSi layer thickness [1]. The coupling between the domains of the adjacent magnetic layers through magneto-static interaction causes the domain walls to align themselves to their peers in the neighboring layers eliminating the magnetic charges from the interior of the films [1]. Magnetic hysteresis loops show a significant drop in coercivity [2]. In patterned samples, the magnetic closure domains display a transition from a modified spike domain to a closure domain structure and the domain rotation starts to become dominant in the magnetization reversal process. As a result Barkhausen noise in ME-sensors is reduced considerably. [1] J. C. Slonczewski, B. Petek, B. E. Argyle, IEEE Transactions on Magnetics (1988) [2] J. McCord and J. Westwood, J. Appl. Phys. 87, 6592 (2000)

MA 50.18 Fri 10:30 Poster D

FMR and MOKE characterization of $Co_{40}Fe_{40}B_{20}$ thin films — •Andres Conca, Jochen Greser, Thomas Sebastian, Stefan Klingler, Britta Leven, and Burkard Hillebrands — FB Physik und Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Magnetic tunneling junctions are being widely used for read heads in hard discs, sensors in robotics or machine controllers. A major breakthrough was provided by the introduction of the alloy CoFeB. With a control of the exact stack composition and of the annealing conditions tunelling magnetoresistance ratios (TMR) as large as 604% [1] have been reported.

Here, we report on the characterization of $Co_{40}Fe_{40}B_{20}$ thin films deposited by magnetron rf-sputtering on SiO_x substrates. The dynamic properties and material parameters were studied by measuring the ferromagnetic resonance using a stripline-vector network analyzer (VNA-FMR). The quasi-static anisotropic switching properties were measured with a magneto-optical Kerr effect setup in longitudinal geometry with a rotational sample stage. A discussion of the values of the saturation magnetization, the Gilbert damping parameter and the exchange constant is presented.

Financial support by the MBWWK of Rhineland-Palatinate and the EFRE programm in the frame of the Spin Technology Platform (STeP) is gratefully acknowledged.

[1] S. Ikeda, *et al*, Appl. Phys. Lett. **93**, 082508 (2006).

MA 50.19 Fri 10:30 Poster D

Post-annealing effects in the Heusler compound Co_2MnSi revealed by magnetoresistance and anomalous Hall effect measurements — •Inga-Mareen Imort, Patrick Thomas, Savio Fabretti, and Andy Thomas — Thin Films and Physics of Nanostructures, Bielefeld University, Germany

Co-based Heusler compounds are prominent candidates for spintronic application due to the predicted half-metallic behavior, i.e. 100% spin polarization at the Fermi level, and the required high Curie temperatures. The degree of structural disorder can affect the spin polarization, and therefore, the electrical and magnetic transport properties. Local disorder as well as crystallographic quality of thin films can be influenced by post-annealing. The Co_2MnSi layers were deposited using dc/rf-magnetron sputtering on single-crystal MgO (001) substrates, and ex-situ annealed at temperatures in the range from 350°C to 500°C. The structural quality of our samples, especially the crossover from amorphous to crystalline structure, was tested by X-ray diffraction scans. After etching typical Hall bar structures, we measured the temperature and field dependent evolution of the anomalous Hall resistance ρ_{AHE} and the longitudinal resistance ρ_{xx} with the sample annealing temperature, in order to investigate the influence of defects, i.e. dislocations and grain boundaries, and atomic disorder on the magnetoresistance and the anomalous Hall effect in Co_2MnSi. This work has been supported by the NRW MIFW.

MA 50.20 Fri 10:30 Poster D

On the micromagnetic origin of the spin-reorientation transition in Ni_xPd_{1-x} alloys — •Daniel Gottlob[1,2], Ingo Krug[1], Florian Nickel[1], Hatice Doganay[1], Stefan Cramm[1], and Claus M. Schneider[1,2] — [1]Peter-Gruenberg Institut 6, Forschungszentrum Juelich, 52425 — [2]Fakultaet fuer Physik, Universitaet Duisburg-Essen, 47057 Duisburg

We chose the model system Ni_xPd_{1-x} to investigate different mechanisms involved in inverse spin-reorientation transitions (iSRTs). The 3d-4d hybridization between Ni and Pd and the strain variation by composition offer a way to tune magnetic anisotropy. Aberration-corrected LEEM-PEEM with its high spatial resolution is the ideal tool to investigate the magnetic domain-structure and do temperature- and composition-gradient dependent studies on microwedges and thin films. By alloying Paladium into Nickel the epitaxial strain of a thin film may be varied and the critical film thickness at which an iSRT occurs can be controlled. Close to the critical thickness the iSRT can also be induced by variation of the temperature. We present first results imaging the iSRT in NiPd by aberration corrected PEEM at the FZ Jülich Beamline UE56/1-sgm at BESSY. We prepared NiPd thin films in situ in a microwedged structure by molecular beam epitaxy. Both elements have been co-deposited using an aperture-shadowing technique to create a thickness wedge on the sample. On this poster we present LEEM and PEEM data mapping the wedge in terms of structural and magnetic properties.

MA 50.21 Fri 10:30 Poster D

Magnetic anisotropy of strained La0.7Sr0.3CoO3 thin films probed by XMCD — •Peter Nagel[1], Michael Merz[1], Felix Eilers[1,2], Dirk Fuchs[1], Hilbert von Löhneysen[1,3], and Stefan Schuppler[1] — [1]KIT, Institut für Festkörperphysik — [2]KIT, Fakultät für Physik — [3]KIT, Physikalisches Institut, Karlsruhe, Germany

The magnetic properties of perovskite-type La1-xSrxCoO3 have their origin in the variety of possible valence and spin states of the Co ion and in strong electronic correlations. Bulk La0.7Sr0.3CoO3 is known to be a ferromagnetic metal below Tc=240 K and to exhibit large Joule magnetostriction. This motivated us to investigate a complementary magnetoelastic effect: the effect of biaxial strain on the magnetization. La0.7Sr0.3CoO3 thin films were grown on lattice-mismatched substrates (LaAlO3 , SrTiO3, MgO and LSAT) by pulsed laser deposition. X-ray diffraction confirmed the films to be subjected to compressive or tensile strain, respectively. Near-edge x-ray absorption fine structure (NEXAFS) and x-ray magnetic circular dichroism (XMCD) at the Co L2,3 edge and the O K edge provided spectroscopic information on the electronic and magnetic structure. Sum rules were used to extract magnetic moments from the XMCD spectra. The difference between in-plane and out-of-plane magnetic moments was found to vary with the biaxial strain. We gratefully acknowledge the Max Planck Institute for Intelligent Systems (E. Goering, T. Tietze, G. Schütz) for the use of their XMCD end station and the synchrotron light source ANKA for the provision of beam time.

MA 50.22 Fri 10:30 Poster D

Correlations between the surface morphology and the atomic structure of thin layers of Fe_3Si on GaAs(001) and their magnetic properties — •Sani Noor[1], Igor Barsukov[2], M. Samet Özkan[1], Lina Elbers[1], Benjamin Geisler[2], Peter Kratzer[2], Michael Farle[2], and Ulrich Köhler[1] — [1]Experimentalphysik IV, AG Oberflächen, Ruhr-Universität Bochum — [2]Fakultät für Physik and Center for Nanointegration (CeNIDE) Universität Duisburg-Essen

Among the FM/SC combinations that represent one possible approach necessary for the realization of spintronic devices Fe_3Si/GaAs is an interesting choice due to its properties like a low lattice mismatch, half-metallic behaviour and high thermal stability.

In this contribution we consider the structural and magnetic proper-

ties of thin near-stoichiometric Fe_3Si layers on GaAs(001) with varying thicknesses. Methods employed include STM, LEED, in situ MOKE, SQUID magnetometry and FMR. Emphasis is laid on the correlations between these properties such the nucleation at low coverage and its superparamagnetic behaviour and the layer morphology at higher coverage and magnetic anisotropies. Furthermore, atomic scale STM data is compared with STM simulations.

MA 50.23 Fri 10:30 Poster D

Pattern formation and transformation in a magnetic model system — •Matthias Kronseder, Martin Buchner, and Christian Back — Universität Regensburg, Deutschland

Magnetic phase transitions in ultra thin films have been subject to intensive studies in the last decade. Particular interest has been dedicated to the spin reorientation transition (SRT) found in some ultra thin magnetic films with a strong perpendicular anisotropy. In addition, the magnetic domain pattern exhibits a distinct evolution, i.e. a transformation between individual phases of those patterns, while approaching the SRT. Here, we concentrate on the dynamics near phase transitions. We use a laboratory based imaging technique with high spatial resolution, which is threshold photoemission magnetic circular dichroism (TP-MCD) in combination with photoemission electron microscopy (PEEM). The magnetic phase transitions of the system Fe/Ni/Cu(001) has been investigated with respect to its temporal and temperature dependence. Furthermore we investigate its behavior in external magnetic fields.

MA 50.24 Fri 10:30 Poster D

Preparation and characterization of ultrathin Ni films on W(110): electronic structure and magnetism — •Henry Wortelen[1], Anke B. Schmidt[1], Martin Weinelt[2], and Markus Donath[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster — [2]Fachbereich Physik, Freie Universität Berlin, 14195 Berlin

An effective way to study the electronic structure of the band ferromagnet nickel at the magnetic phase transition is to lower the Curie temperture by going from bulk samples to ultrathin films.

In this contribution, we present a comprehensive investigation of ultrathin nickel films grown on W(110), as the film thickness is reduced from 10 to 1 monolayer. A combined study with scanning tunneling microscopy, low-energy electron diffraction, magneto-optic Kerr effect, and spin-resolved inverse photoemission reveals the close relation between film thickness, morphology, electronic structure, and magnetism. Our results indicate changes in coercivity, spin asymmetry, and spectral intensity of surface states as a function of film thickness and quality.

MA 50.25 Fri 10:30 Poster D

An oxide MBE system as a user instrument for quasi *in-situ* neutron reflectometry studies — •Sabine Pütter[1], Alexandra Steffen[1], Stefan Mattauch[1], and Thomas Brückel[1,2] — [1]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at FRM II, Lichtenbergstr. 1, 85747 Garching — [2]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institute, JCNS-2, PGI-4: Scattering methods, Forschungszentrum Jülich GmbH, 52425 Jülich

Molecular Beam Epitaxy (MBE) is a fascinating method to deposit high quality epitaxial thin films. The Jülich Centre for Neutron Science (JCNS) opens its state-of-the-art MBE system at the FRM II in Garching to friendly users who are interested in preparing tailored samples for the investigation with the JCNS neutron reflectometer MARIA (magnetic reflectometer with high incident angle) or other methods.

The MBE is equipped with 6 effusion cells, two electron guns for electron-beam evaporation with 4 crucibles each and an oxygen plasma source. Standard in-situ surface analysis tools like reflection high and low energy electron diffraction, Auger electron spectroscopy analysis are also available.

We will give examples for high quality metal and complex oxide thin film systems like e.g. $La_{1-x}Sr_xMnO_3/SrTiO_3$ with focus on stoichiometry, morphology and thickness and give detailed information about what kind of samples we can provide to you.

MA 50.26 Fri 10:30 Poster D

Roughness investigations of a CoFeB-MgO nanowire — •Tim Zacke[1], Tomek Schulz[1], Su Jung Noh[1], Benjamin Krüger[1], Capucine Burrowes[1], Dafiné Ravelosona[2], and Matthias Kläui[2] — [1]Institut of physics, University of Mainz, Mainz, 55128, Germany — [2]Institut d'Elecronique Fondamentale, Univerité Paris Sud, Orsay, 91405, France

We have investigated the impact of roughness on the domain wall dynamics in a nanowire, consisting of the multilayer stack CoFeB/MgO, which exhibits a high magnetic perpendicular anisotropy. These investigations were carried out by numerical simulations using the object oriented micro magnetic framework (OOMMF) based on the Landau-Lifshitz-Gilbert (LLG) - equation and the micromagnetic model. By varying the key roughness parameters (correlation length and amplitude), we determine the dependence on the pinning strength (wall propagation field) on these parameters and correlate the wall width with these. To compare with experimental results, we nucleate a DW in a CoFeB/MgO by an Oersted field generated by a gold wire on top of the magnetic wire. We then measure the wall propagation field at variable temperature down to 4K. This allows us to determine by comparison between experimental and theoretical results the effective magnetic roughness of the wire. Comparison to high resolution microscopy images allows us to ascertain to what extent the visible roughness and the magnetic roughness correlate yielding insights on the homogeneity of the magnetic properties at the wire edge.

MA 50.27 Fri 10:30 Poster D

Investigations of magnetic properties of thin (Mn,Zn)Fe2O4 films on SrTiO3 — •Martin Welke[1], Stephan Borek[2], Kerstin Brachwitz[3], Annette Setzer[3], Michael Lorenz[3], Pablo Esquinazi[3], Marius Grundmann[3], Karl-Michael Schindler[2], Angelika Chassé[2], and Reinhard Denecke[1] — [1]Wilhelm-Ostwald-Institut für Physikalische und Theoretische Chemie, Universität Leipzig — [2]Institut für Physik, Universität Halle — [3]Institut für Experimentelle Physik II, Universität Leipzig

The work presented deals with Mn-Zn ferrite (Mn0.5Zn0.5Fe2O4) film on Strontiumtitanate (SrTiO3) as preparative studies towards multiferroic layer systems. The ferrite film was prepared by PLD in 6*10-5 mbar O2 at a substrate temperature of 620 °C. XRD phi scans reveal an in plane epitaxial relationship of [100](Mn,Zn)Fe2O4 || [100]SrTiO3. Subsequently SQUID magnetometry measurements are planned in order to obtain magnetization loops. Furthermore, angular dependent XMCD measurements at remanent magnetization have been carried out. There was no remanent out-of-plane magnetization observed in XMCD. In addition, XMLD measurements have been performed in order to proof the antiferromagnetic coupling between Fe atoms. While the measured Mn L2,3 spectra corresponded well to bulk spectra published in literature [1], the Fe L2,3 spectra proof to exhibit defect induced magnetism in XMCD. Theoretical simulations are performed to obtain a detailed understanding. [2]

[1] M. Magnuson et al., Phys. Rev. B, 2006, 74, 172409
[2] E. Stavinski and F.M.F. de Groot, Micron, 2010, 687

MA 50.28 Fri 10:30 Poster D

Synthesis and properties of ultrahtin, epitaxial, B2 ordered FeRh thin films — •Ralf Witte[1,2], Richard Brand[1], Robert Kruk[1], and Horst Hahn[1,2] — [1]Institute of Nanotechnology, Karlsruhe Institute of Technology — [2]Joint Laboratory Nanomaterials, Materials Science Departement, TU Darmstadt

The B2 ordered phase (CsCl structure) of equiatomic FeRh alloys possess interesting magnetic properties. It is antiferromagnetically (AFM) coupled at room temperature and shows a transition to a ferromagnetic phase (FM) at about 400 K. This behavior has been observed in bulk material and as well in thin films. Generally, stabilization of the FM phase is associated with the Rh spin state; in the AFM phase the magnetic moment on the Rh atom is zero, while it gets polarized in the FM state. It has been calculated [1] that the FM state can be stabilized at room temperature in (freestanding, single crystalline) films with a thickness below a critically value of nine atomic layers. This effect is attributed to the increased polarizability of the Rh atoms at the surface, which in turn stabilizes the FM state in the entire film. We present results on the synthesis and properties of such ultra thin, epitaxial FeRh films on MgO substrates prepared by electron beam evaporation. The samples are characterized using e.g. high-resolution X-ray diffraction, atomic force microscopy, SQUID magnetometry, X-ray photo electron spectroscopy and Fe Moessbauer spectroscopy. [1] S. Lounis, Phys. Rev. B 67, 094432 (2003)

MA 50.29 Fri 10:30 Poster D

Magnetization reversal of percolated ferrimagnetic Fe-Tb nanodot arrays — •Christian Schubert[1], Phani Arekapudi[1], Birgit Hebler[1], Florin Radu[2], Marcus Daniel[1], and Manfred

Albrecht[1] — [1]Institute of Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]Department for Magnetization Dynamics, Helmholtz Zentrum Berlin, Germany

Amorphous ferrimagnetic rare earth-transition metal alloys with high perpendicular magnetic anisotropy are suitable in hard disk drives to overcome the superparamagnetic limit. In particular for thermally assisted bit patterned recording media [1] amorphous Fe-Tb is a promising functional layer providing good adjustability of anisotropy, Curie temperature, and saturation magnetization [2].

We present an investigation of structural and magnetic properties of percolated amorphous Fe-Tb nanodots produced by co-deposition on pre-patterned substrates with pillar diameters of 30 nm and a period of 60 nm. The magnetic films follow closely the morphology of the pre-pattern forming exchange coupled nanodots and trench material. Despite the exchange interaction the nanodots reveal a single domain magnetization state and reverse via a more coherent rotation process as deduced from in-field MFM and angular MOKE measurements. Contrary to this the reversal of the continuous trench material is dominated by domain wall motion and the coercive field is enhanced due to pinning effects caused by the nanodot array.

[1] Akagi et al., J. Magn. Magn. Mater. 324, 309 (2012)
[2] Mimura et al., IEEE Trans. Magn. 12, 779 (1976)

MA 50.30 Fri 10:30 Poster D

Investigation of Domain Pattern and Magnetisation Reversal Process in Hexagonal Nano-Scaled Antidot Lattices — •Joachim Gräfe[1], Felix Häring[2], Ulf Wiedwald[2], Paul Ziemann[2], Ulrich Nowak[3], Gisela Schütz[1], and Eberhard Goering[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [2]Department of Solid State Physics, Ulm, Germany — [3]Department of Physics, Konstanz, Germany

Antidot lattices in magnetic materials can be a way to form artificial magnonic lattices as an approach towards spin-wave filters for spintronics [1]. Furthermore, the introduction of an antidot lattice provides a significant modification of static properties of the samples like the coercivity and magnetic anisotropy [2]. In this work we present results from investigations into the static regime of antidot lattice properties of in-plane (Fe) and out-of-plane (GdFe) systems. Results from x-ray microscopy indicate control over the formation and propagation of magnetic domains by the antidot pattern. Angular and spatially resolved MOKE measurements prove that the easy axes orientation is governed by the antidot lattice geometry, resulting in a six-fold symmetry of preferential magnetic axes. We present two distinct magnetisation reversal mechanisms occurring along the easy and hard axes in the antidot lattice.

[1] B. Lenk et al., Phys. Rep. 507 (2011) 107-136
[2] G. Ctistis et al., Nano Lett. 9 (2009) 1-6

MA 50.31 Fri 10:30 Poster D

Magnetic properties of Co/Pt multilevel systems — •Patrick Matthes, Benno Oehme, Robert Rückriem, and Manfred Albrecht — Chemnitz University of Technology, Chemnitz, Germany

For both fundamental and technological reasons multilevel film systems with perpendicular magnetic anisotropy has gained importance in recent research. These structures may have applications as storage devices [1], pseudo spin valves or magnetic field sensors [2, 3]. In this study ferromagnetic layers of Co/Pt multilayer stacks with various coercivities separated by a non magnetic Pt-spacer which ensures exchange decoupling have been prepared by dc-magnetron sputtering at room temperature. These flat films have been investigated by Vibrating Sample Magnetometer, Magnetic Force Microscopy and Magnetoresistance measurements to analyze the magnetic switching behaviour and magnetoresistance effect. Furthermore patterned samples with periods below 100 nm have been prepared to investigate the influence of reduced dimensions on the switching behaviour and thermal stability. This study is further supported by micromagnetic simulations.

[1] M. Albrecht al., J. Appl. Phys. **97**, 103910 (2005)
[2] J.F. Feng et al., J. Magn. Magn. Mater. **324**, 2298 (2012)
[3] L. You et al., Appl. Phys. Lett. **100**, 172411 (2012)

MA 50.32 Fri 10:30 Poster D

Artificial spin-ice systems prepared by focused electron beam induced deposition. — •Evgeniya Begun, Fabrizio Porrati, and Michael Huth — Physikalisches Institut, Goethe-Universität, D-60438 Frankfurt am Main, Germany

Spin-ice systems are interesting for the study of fundamental aspects of magnetic monopoles, as well as for magnetic information processing. Besides of the rather narrow class of materials with ice-type magnetic disorder, there exists the possibility of artificial spin-ice creation. Here we present first results on the preparation of cobalt-based artificial spin-ice structures of different configurations grown by focused electron beam induced deposition (FEBID) using the precursor dicobaltoctacarbonyl $Co_2(CO)_8$. The obtained spin-ice structures are in the form of two-dimensional regular arrays of elongated magnetic cobalt islands, which have a metal content of about 70-85 at.%. For the optimization of a one-domain state in each individual Co element the length (from 100 to 500 nm), the width (from 30 to 50 nm), the thickness (from 25 to 50 nm) and the lattice constant (from 200 to 400 nm) have been varied. The arrays have been grown to cover areas from 1 to 10 μm^2 in order to exclude edge effects. First results of magnetic force microscopy measurements done at room-temperature are presented.

MA 50.33 Fri 10:30 Poster D

Spin structure manipulation in nickel nanostructures by magneto-elastic coupling to piezoelectric PMN-PT substrates — •Simone Finizio[1], Michael Foerster[1], Carlos A. F. Vaz[1,2], Tetsuya Miyawaki[3], Joshua L. Hockel[4], Gregory P. Carman[4], and Mathias Kläui[1] — [1]Institut für Physik, Johannes Gutenberg Universität, Mainz, Germany — [2]SwissFEL, Paul Scherrer Institut, Villigen PSI, Switzerland — [3]Department of Crystalline Materials Science, University of Nagoya, Nagoya, Japan — [4]Department of Mechanical and Aerospace Engineering, University of California, Los Angeles, USA

In recent years, there has been an increasing interest in current-less control of magnetization for reduced energy consumption in memory devices. One possible route to achieve such goal is given by the magneto-elastic coupling, through the exploitation of voltage-driven piezoelectric effects to manipulate the magnetization of a ferromagnetic thin film grown on a piezo-substrate. Here, we report XMCD-PEEM imaging of Ni ring-shaped nanostructures grown on PMN-PT. By applying an out-of-plane electric field, a piezoelectric strain is induced in the plane of the film, leading to reproducible modifications of the spin structure due to strain-induced anisotropy in Ni. The characterization shows a clear influence of the piezoelectric strain on the magnetization of the Ni nanostructures, where the nucleation of magnetic domains to 45° with respect to the applied strain direction is observed.

MA 50.34 Fri 10:30 Poster D

Magnetic vortices in permalloy cap structures in confined geometry — •Dennis Nissen[1], Mi-Young Im[2], Peter Fischer[2], and Manfred Albrecht[1] — [1]Institute of Physics, Chemnitz University of Technology, D-09126 Chemnitz, Germany — [2]Center for X-ray Optics, Lawrence Berkeley National Laboratory, California 94720, USA

Vortex states, which are characterized by the chirality of the in-plane magnetization and the out-of-plane component of the vortex core[1], are of great fundamental importance and relevant for application. One approach to realize such magnetic vortex states is to manufacture large arrays of spherical SiO_2-particle monolayers followed by film deposition of permalloy. In this way, it is possible to obtain magnetic cap structures on the particles forming vortex states[2].

We will present the fabrication process of spherical SiO_2-particle monolayers with a particle diameter in the range between 50 nm and 4,5 μm, which act as templates for further film deposition, and furthermore the possibility to create particular particle arrangements using additional pre-patterns. Moreover, we will show investigations of the magnetic properties studied by magnetic force microscopy and magneto-optic Kerr effect magnetometry. In this context particular attention is paid to the magnetic reversal mechanism of a vortex as a function of external field. In addition, recent studies on the formation process of vortex states in large arrays of cap structures using magnetic transmission X-ray microscopy will be presented. [1]T. Shinjo et al. Science 289 (2000) 930. [2]R. Streubel et al. Phys. Rev. B 85, (2012) 174429.

MA 50.35 Fri 10:30 Poster D

Dynamic response of periodic magnetic domain patterns in submicron sized Co2MnGe-Heusler wires — •Katherine Gross, Frank Brüssing, Kurt Westerholt, and Hartmut Zabel — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum,Germany

We have investigated the dynamic response of periodic magnetic domain patterns in submicron sized Co2MnGe-Heusler ferromagnetic wires by measuring the in-phase and out-of phase magnetic suscep-

tibility via the magneto-optical Kerr effect with an ac-magnetic field applied parallel or perpendicular to the wire axis. In magnetic remanence the magnetization in the Co2MnGe wires aligns along the growth induced uniaxial anisotropy axis transverse to the wire axis, forming highly regular domain patterns with 180° domain walls. The application of an ac-field perpendicular to the wire axis results in a oscillating motion of the domain walls (DW) along the wire axis. For small field amplitudes just above the depinning field the DW dynamics can be described by a slide-like motion and an analytical expression can be used to extract the depinning field and the domain wall mobility. When applying the ac-magnetic field along the wire axis the magnetization in the perpendicular domains responses by coherent rotation towards the direction of the wire axis. In both configurations the complex ac-susceptibilty is described by a Cole-Cole type of relaxation time approach.

MA 50.36 Fri 10:30 Poster D

Domain wall magnetoresistance and depinning in $La_{0.66}Sr_{0.33}MnO_3$ nanowires — Michael Foerster[1], Luis Peña[1], •Simone Finizio[1], Laurence Mechin[2], Felix Büttner[1,3], André Bisig[4], Stefan Eisebitt[3], and Mathias Kläui[1] — [1]Institut für Physik, Johannes Gutenberg Universität, Mainz, Germany — [2]GREYC, UMR 6072, CNRS-ENSICAEN-UCBN, Caen Cedex, France — [3]Institut für Optik und Atomare Physik, Technische Universität Berlin, Berlin, Germany — [4]SwissFEL, Paul Scherrer Institut, Villigen PSI, Switzerland

Magnetic domain walls (DWs) and their reliable displacements are key ingredients for novel magnetic memory and sensing devices with switching by domain wall motion. $La_{0.66}Sr_{0.33}MnO_3$ (LSMO) is a ferromagnetic metal with a high spin polarization, which promises large spin transfer torque (STT) effects, and a T_c close to room temperature (370K) that allows for the investigation of magnetotransport and STT effects with tuneable parameters. We have measured the magnetoresistance of LSMO nanostructures at 4.3K, observing the magnetoresistance associated with DWs in an LSMO wire by comparing hysteresis loops with fields along different directions. Depinning of DWs was observed as function of the applied magnetic field along the wire, with good quantitative agreement with simulations. The injection of current pulses leads to changes in the signal that are probably due to local changes in the magnetization, which occur due to Joule heating combined with the low T_c.

MA 50.37 Fri 10:30 Poster D

Magnetization Reversal Mechanisms in Co-Antidot Arrays — Manuel Langer[1], •Rantej Bali[1], Ewa Kowalska[1], Andreas Neudert[1], Kilian Lenz[1], Kay Potzger[1], Mikhail Kostylev[2], Adekunle Adeyeye[3], Jürgen Fassbender[1], and Jürgen Lindner[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., 01328 Dresden, Germany — [2]School of Physics, University of Western Australia, Crawley 6009, Australia — [3]Department of Electrical and Computer Engineering, National University of Singapore, 117576 Singapore

Co-antidots with holes arranged in the form of a square lattice, with lattice parameter of 415 nm and hole diameter $d = 145$ to 255 nm were fabricated using DUV photolithography. For arrays with film thickness of 50 nm, the angular dependence of the saturation field (H_s) shows presence of four-fold anisotropy with the hard axes along the <01> directions and easy axes was along the diagonal <11> directions. Spikes in the H_s were measured along the intermediate <12> directions. Kerr microscopy suggests that the reversal mechanism along the <01> is domain-wall (DW) depinning followed by propagation within the continuous channels along the <01>, whereas along the <11> the mechanism tends towards nucleation and growth. We postulate that the H_s-spikes occur because DW-propagation requires domino-like spin-reorientations through the continuous channels, whereas nucleation can only occur when a coherent region is formed with the spins oriented along the applied field. The frustration caused by the two possible spin-reorientation paths results in the larger H_s. We attempt to model these mechanisms using OOMMF and investigate the influence of varying *d*.

MA 50.38 Fri 10:30 Poster D

All-optical switching in CoTb alloys: composition and thickness dependent studies — •Ute Bierbrauer[1], Sabine Alebrand[1], Michel Hehn[2], Matthias Gottwald[2,3], Daniel Steil[1], Daniel Lacour[2], Mirko Cinchetti[1], Martin Aeschlimann[1], Eric E. Fullerton[3], and Stéphane Mangin[2] — [1]Dep. of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany — [2]IJL, Université de Lorraine, Nancy, France — [3]University of California, San Diego, USA

All-optical switching (AOS), i.e. switching of magnetic domains by means of circularly polarized fs laser pulses, has been demonstrated up to now only in GdFeCo [1]. However, it is still not clear if AOS is related to the specific properties of GdFeCo or if it also occurs in other materials.

We focus on AOS in high anisotropy CoTb alloys [2], demonstrating that AOS is possible for a certain Tb concentration range. Interestingly this concentration range corresponds to the one where the compensation point is above room temperature. We further investigate the dependence of AOS on the film thickness. Overall we discuss possible influences of the material specific magnetic properties, like e.g. the coercive field and the saturation magnetization. We find indications that such properties cannot be ignored, when trying to get a deeper understanding of AOS.

[1] C.D. Stanciu et al., PRL 99, 047601 (2007) [2] S. Alebrand et al., APL 101, 162408 (2012)

MA 50.39 Fri 10:30 Poster D

Control of Magnetic Domains and Domain Walls by Thermal Gradients — •Martin Stärk, Johannes Boneberg, Mikhail Fonin, and Elke Scheer — Department of Physics, University of Konstanz, Germany

Investigation and control of domains and domain walls in magnetic materials is very important for the understanding of the magnetism in thin films and nanostructures as well as for the development of future spintronic devices. Recently, the interaction between spin-currents or magnetic fields and domain configurations attracted considerable attention. With respect to new data storage media techniques as heat assisted magnetic recording, thermal effects in spin-polarized materials and nanostructures might get important.

From the theoretical point of view, nanometer-sized domain walls can be moved with a speed of 50 m/s by temperature gradients of around 50 K/μm (D. Hinzke et al., Phys. Rev. Lett. 107, 027205 (2011)). In order to investigate this behavior experimentally, we use ns-pulsed laser interference to generate temperature patterns with variable periods between 200 nm and 20 μm and thermal gradients of up to several hundred K/μm on thin films of ferromagnetic metals.

Using this technique, we study the effects on out-of-plane Co/Pd multilayer systems with magnetic force microscopy before and after the illumination. Thereby, a change in the domain distribution is observed.

MA 50.40 Fri 10:30 Poster D

investigation of magnetic domain structure and domain wall in Co2Mn0.6Fe0.4Si — •tomohiro koyama[1], phillip pirro[1], thomas brächer[1], thomas sebastian[1], ikhtiar i[2], yusuke ohdaira[2], takahide kubota[3], hiroshi naganuma[2], mikihiko oogane[2], yasuo ando[2], and burkard hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Applied Physics, Graduate School of Engineering, Tohoku University, 980-8579, Sendai, Japan — [3]WPI Advanced Institute for Materials Research, Tohoku University, 980-8577, Sendai, Japan

The interaction between magnetic domain walls (DW) and spin waves is much attractive from the viewpoint of physical interests and applications. The full Heusler compound Co2Mn0.6Fe0.4Si (CMFS) is one of the suitable materials to investigate it because of its long decay length of spin waves. For the advance of the research, we have characterized domain structures and DWs in CMFS. The micro structures were fabricated from CMFS film with 30 nm thickness sputtered on MgO substrate by electron beam lithography and ion etching. The magnetic domain structure and DWs in CMFS were directly observed by using magnetic force microscopy. We found that in a square pad the Landau closure domain was formed by oscillatory reducing the external field to zero. In addition, the creation of a single DW in an L-shaped wire was performed. The effect of excited spin waves on these domain structures will be discussed. T.K. gratefully acknowledges the Alexander von Humboldt foundation for a postdoctoral fellowship.

MA 50.41 Fri 10:30 Poster D

Brillouin light scattering investigations of perpendicular standing spin waves at Au and Ag nanoparticles on top of a $Ni_{81}Fe_{19}$ film — •Thomas Meyer, Björn Obry, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

In the last decades localized plasmons excited in metallic nanoparticles providing a local field enhancement were used to increase the signal strength and spatial resolution like in the case of surface enhanced Raman spectroscopy. We present Brillouin light scattering (BLS) studies of perpendicular standing spin waves in a thin $Ni_{81}Fe_{19}$ film with single Au and Ag nanoparticles on top. An increase of the BLS signal as well as a frequency shift of the spin waves due to the metal nanoparticles is observed. To describe this, and besides their plasmonic properties, other influences of the nanoparticles on the magnetization dynamics have to be taken into account. In order to identify the contributions to the observed signal changes, investigations using different materials, sizes and shapes of the structures have been performed.

MA 50.42 Fri 10:30 Poster D

Magnetoresistance of an individual ferromagnetic nanotube under microwave irradiation — •Tobias Stückler[1], Florian Heimbach[1], Rupert Huber[1], Daniel Rüffer[2], Eleonora Russo-Averchi[2], Martin Heiss[2], Anna Fontcuberta i Morral[2], and Dirk Grundler[1,3] — [1]Physik-Dep. E10, TU München, D-85748 Garching — [2]LMSCX, IMX, EPF Lausanne, CH-1015 Lausanne — [3]STI, EPF Lausanne, CH-1015 Lausanne

The magnetic states predicted for ferromagnetic nanotubes have generated great interest in both theoretical and experimental nanomagnetism research. Using atomic layer deposition, we have prepared 40 nm thick Ni nanotubes by conformal coating of single-crystalline GaAs nanowires with a diameter of about 300 nm. Subsequently, we position a several-μm-long nanotube on a Si substrate and integrate four metallic contacts. At room temperature, we measure the magnetic field dependent resistance under microwave irradiation using a neighboring antenna. We report on characteristic resonance features which we attribute to excited spin waves. Financial support by the EC (FP7/2007-2013) under Grant Agreement No. 228673 (MAGNONICS), the DFG via NIM, the SNF, and QSIT is gratefully acknowledged.

MA 50.43 Fri 10:30 Poster D

Azimuthal Spin-Wave Modes in Permalloy Coated Glass Fibers — •Lukas Nagrodzki, Felix Balhorn, Wolfgang Hansen, and Stefan Mendach — Institut für Angewandte Physik, Universität Hamburg, Germany

We show by means of broadband microwave spectroscopy that Permalloy cylinders with micron-sized diameters exhibit pronounced azimuthal spin-wave modes, which can be tuned over several GHz by an external magnetic field. For the preparation of these devices we have deposited thin layers of Permalloy on glass fibers with diameters of a few microns by thermal evaporation. They show resonant behavior with multiple resonances when magnetized along the fiber axis. We interpret those resonances as interfering spin waves propagating in azimuthal direction. The data can be well reproduced using an analytical model for spin waves in thin films employing periodic boundary conditions as also used for rolled-up Permalloy spin-wave resonators previously introduced by our group [1, 2].

Financial support by the Deutsche Forschungsgemeinschaft via SFB668 is acknowledged.

[1] F. Balhorn et al., PRL **104**, 037205 (2010); [2] F. Balhorn et al., APL **100**, 222402 (2012)

MA 50.44 Fri 10:30 Poster D

Time-Resolved Magnetic Imaging in an Energy-Filtered, Aberration-Corrected Photoemission Electron Microscope — •Florian Nickel[1], Daniel Gottlob[1], Ingo Krug[1], Alexander M. Kaiser[2], Denys Makarov[3], Gungun Lin[3], Stefan Cramm[1], Hatice Doganay[1], Oliver G. Schmidt[3], and Claus M. Schneider[1,4] — [1]Peter Grünberg Institut 6, Research Center Jülich, 52425 Jülich — [2]SPECS Surface Nano Analysis GmbH, 13355 Berlin — [3]Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstr. 20, 01069 Dresden — [4]Fakultät für Physik und Center for Nanointegration Duisburg-Essen (CeNIDE), Universität Duisburg-Essen, 47048 Duisburg

Information technology relies on reliable storage and fast switching of material states. These states can be governed either by magnetic or electrical degrees of freedom, which offers a wide variety of design concepts. Common to all storage concepts is that manipulation of the information state takes place on a characteristic time and length scale, which is in the picosecond respective nanometer range. All requirements are combined in the method of time-resolved photoemission microscopy (TR-PEEM). Recently, we installed a state-of-the-art PEEM with energy-filtering system and aberration corrector (FE LEEM-P90 AC by SPECS) at the FZ-Jülich Beamline UE56/1-SGM @ BESSY. In this poster we present the extension of the microscope setup for synchrotron pump-probe measurements. We will present details about the technical performance of the setup as well as first results on magnetization dynamics in ferromagnetic nanoelements.

MA 50.45 Fri 10:30 Poster D

Supercritical parametric generation in a $Ni_{81}Fe_{19}$ microstripe — •Thomas Brächer[1,2], Philipp Pirro[1], Alexander A. Serga[1] und 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, 67663 Kaiserslautern, Germany

Parallel parametric amplification [1] is an alternative method to excite spin-wave dynamics in microstructured elements, as recent experiments have shown the applicability of the technique to micron-sized $Ni_{81}Fe_{19}$ structures.[2,3]

We report on the supercritical evolution of parametrically generated spin-wave modes as a function of applied microwave power in a $Ni_{81}Fe_{19}$ microstripe employing parallel parametric amplification. The experimental observation is carried out using Brillouin light scattering microscopy. We find that depending on the applied external magnetic field, different transitions of the observed spin-wave mode profiles, like a transition from the first to the second transverse mode at low magnetic fields, can be found.

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] H. Ulrichs et al., Phys. Rev. B 84, 094401 (2011)

MA 50.46 Fri 10:30 Poster D

Spin pumping in YIG/Pt bilayer — •Markus Härtinger[1], Sibylle Meyer[2], Stephan Geprägs[2], Matthias Opel[2], Hans Huebl[2], Sebastian T.B. Goennenwein[2], Christian Back[1], and Georg Woltersdorf[1] — [1]Department of Physics, Universität Regensburg, 93040 Regensburg, Germany — [2]Walter-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

Spin pumping adds an additional damping mechanism to the instinsic damping propierties of a magnetization precession by emission of an angular momentum flow. When the latter is relaxed, e.g. in a material with large spin orbit scattering like Pt, the spin current is efficiently damped, resulting in an increased FMR linewidth. Here we report on this effect in a bilayer of the insulating ferrimagnet Yttrium Iron Garnet (YIG) and platinum (Pt). The samples consist of ultrathin epitaxial YIG layers grown by pulsed laser deposition on GGG(111) (Gadolinium Gallium Garnet) substrates. The platinum capping layers are deposited in-situ. We have determined the magnetic properties by performing ferromagnetic resonance (FMR) measurements on YIG layers as well as on bilayer YIG/Pt samples in a frequency range from 2 to 20 GHz. In the pure YIG samples we find very narrow resonance lines corresponding to a Gilbert damping constant of approximately $\alpha = 0.001$. Due to the spin pumping an additional platinum layer on top of the YIG samples results in a significant broadening of the FMR linewidth proportional to the microwave frequency. In order to substantiate this we measured the platinum and YIG thickness dependence of this additional damping.

MA 50.47 Fri 10:30 Poster D

Inverse Spin Hall Effect in $Ni_{80}Fe_{20}$ / Normal Metal Bilayers — •Martin Obstbaum, Markus Härtinger, Thomas Meier, Fabian Swientek, Christian H. Back, and Georg Woltersdorf — Institut für Experimentelle und Angewandte Physik, Universität Regensburg,93040 Regensburg, Germany

We investigate the inverse spin Hall effect in $Ni_{80}Fe_{20}$/normal metal bilayers. Pure spin currents are generated by spin pumping at ferromagnetic resonance and a dc-voltage is measured in the plane of the bilayer system. For Pt and Au as normal metals the observed inverse spin Hall effect and the corresponding spin Hall angle are consistent with literature values. In the case of $Ni_{80}Fe_{20}$/Ta - bilayers a giant spin Hall angle has recently been reported [1], however, we do not detect a measurable voltage due to the inverse spin Hall effect in $Ni_{80}Fe_{20}$/Ta bilayers. In fact, from our angle and temperature dependent measurements we conclude that for $Ni_{80}Fe_{20}$/Ta bilayers the voltage generated at ferromagnetic resonance is solely a consequence of the anisotropic magnetoresistance.

[1] Liu et al. Science 336, 555 (2012)

MA 50.48 Fri 10:30 Poster D

Femtosecond spin dynamic in ferromagnetic Fe/Ru/Ni nanopillars — •Jorge Martin[1,2], Marco Battiato[4], Roman Adam[1,2], Dennis Rudolf[1,2], Chan La-o-vorakiat[3], Justin M. Shaw[5], Emrah Turgut[3], Pablo Maldonado[4], Stefan Mathias[3,6], Patryk Grychtol[3], Hans T. Nembach[5], Thomas J. Silva[5], Martin Aeschlimann[6], Henry C. Kapteyn[3], Margaret M. Murnane[3], Peter M. Oppeneer[4], and Claus M. Schneider[1,2] — [1]Peter Grünberg Institut PGI-6 ,Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA, Fundamentals of Information Technology — [3]Department of Physics and JILA, University of Colorado and NIST, Boulder, CO, USA — [4]Department of Physics and Astronomy, Uppsala University, SE-75120 Uppsala, Sweden — [5]Electromagnetics Division, National Institute of Standards and Technology, Boulder, CO, USA — [6]University of Kaiserslautern and Research Center OPTIMAS, 67663 Kaiserslautern, Germany

High harmonics generation, driven by a femtosecond pulsed laser, has provided a unique insight into the spin dynamics in ferromagnetic multilayered samples, due to the development of ultrafast probing techniques that combine femtosecond time resolution with element selectivity. We patterned Fe/Ru/Ni layers into an array of equally spaced nanopillars. Following optical pump, we employed the resonant transversal magneto optical Kerr effect for tracing the response of Fe and Ni layers separately, to gain deeper comprehension of the interplay of optically induced demagnetization-magnetization processes.

MA 50.49 Fri 10:30 Poster D

Ultrafast Demagnetization in a Kondo-Lattice System — •Alexander Baral and Hans-Christian Schneider — University of Kaiserslautern

We present theoretical results on the magnetization dynamics after ultrashort pulse excitation in a Kondo-lattice model, i.e., a system of 2D carriers coupled by an exchange interaction to a virtual lattice of localized spins. For the itinierant carriers, we include a spin-orbit coupling of the Rashba type as well as carrier-carrier and carrier-phonon scattering. In the framework of this model and starting from a mean-field description and using a dynamical exchange splitting, we investigate the magnetization dynamics after ultrashort-pulse excitation. Such an excitation leads to a demagnetization dynamics reminiscent of that found in 3d- and 4f-ferromagnetic metals.[1] We compute time- and momentum-dependent carrier distribution functions from carrier-carrier and carrier-phonon Boltzmann scattering integrals. In addtion, in our model, the exchange splitting is time-dependent, so that also the spin-mixing changes with time. It is shown that the dynamical exchange splitting and also the dynamical change of the spin mixing hava an important qualitative and quantitative influence on the demagnetization and remagnetization dynamics. [1] Koopmans, B. et al., Nature Mater. 9, 259*265 (2010).

MA 50.50 Fri 10:30 Poster D

Influence of hot electrons on the ultrafast quench of magnetization in Ni and FePt — •Martin Lüttich[1], Jakob Walowski[1], Andreas Mann[1], Johannes Mendil[1], Markus Münzenberg[1], Unai Atxitia[2], and Oksana Chubykalo-Fesenko[2] — [1]I. Physikalisches Institut Georg-August-Universität Göttingen, Göttingen, Germany — [2]Instituto de Ciencia de Materiales de Madrid, Madrid, Spain

Since the first investigation of ultrafast magnetization dynamics in 1996, the question on driving mechanism(s) is still not resolved entirely. According to the predicted superdiffusive spin transport, we investigate the influence of hot electrons on the relative demagnetization.

Magnetization dynamics of an in-plane magnetized Ni film and an out-of-plane magnetized FePt film is measured using the all-optical pump-probe technique for various pump pulse fluences. To clarify the influence of hot electrons on the relative demagnetization, experiments with temporarily stretched pump pulses from 50 fs up to 2.5 ps are performed. These results are compared to simulations based on the Landau-Lifshitz-Bloch equation, which is based on the thermal model, and featured by the consideration of two spin temperature dependent relaxation times $\tau_{||}$ and $\tau_{\perp}$. The electron temperature needed as input for the simulations is obtained from independent experiments on reflectivity dynamics. Compared to experiments, using ultrashort 80 fs pump pulses containing same energy per pulse, a lower maximum electron temperature is reached, but it is maintained for a longer time with the longer pump pulses.

MA 50.51 Fri 10:30 Poster D

Femtosecond spin dynamics in ferromagnet/metal bi-layers — •Daniel Simon[1,2], Roman Adam[1,2], Moritz Plötzing[1,2], Christian Weier[1,2], Dennis Rudolf[1,2], and Claus M. Schneider[1,2] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Gemany — [2]JARA - Fundamentals of Future Information Technologies

Laser-induced demagnetization of ferromagnetic films is known to be an effect on the timescale of a few hundred femtoseconds. Among many proposed mechanisms, spin-flip processes [1] and spin-superdiffusion [2, 3] have been proposed to explain these ultrafast developments. In the presented work, we investigate spin dynamics of ferromagnet (4nm)/metal (20nm) bi-layers in a backside-pump/frontside-probe setup using infrared (800nm) pump and blue (400nm) probe laser pulses. This geometry allows us to probe the magnetization dynamics spatially separated from the pumping. Our measurements show an influence of the pump pulse on the magnetization even though a direct pumping is suppressed by the metal layer, giving rise to an interpretation based on a non-local effect, namely spin currents.

[1] B. Koopmans, et al. Nature Materials 9, 259 (2010).
[2] D. Rudolf, et al. Nature Communications 3, 1037 (2012).
[3] M. Battiato, et al. Phys. Rev. Lett. 105, 027203 (2010).

MA 50.52 Fri 10:30 Poster D

Comparing the ultrafast demagnetization of Gadolinium and Terbium — •Martin Teichmann[1,2], Robert Carley[1,2], Björn Frietsch[1,2], Kristian Döbrich[1,2], Jan Wolter[1,2], John Bowlan[1,2], and Martin Weinelt[1,2] — [1]Freie Universität Berlin — [2]Max-Born-Institut Berlin

The laser-driven ultrafast demagnetization dynamics of the rare earths gadolinium and terbium show distinct behavior. We performed time- and angle-resolved photoemission experiments using high-order harmonics on Gd and Tb, revealing the occupied band structure in the 3rd Brillouin zone. By following the time evolution of the spin-split valence bands individually, we are able to separate the different effects acting during demagnetization, namely spin transport and electron-phonon scattering, while simultaneously monitoring the magnetization via the exchange splitting.

We see that the dynamics of the electron-phonon scattering is very similar in Gd and Tb, while the spin transport accounts for their differences.

MA 50.53 Fri 10:30 Poster D

A Non-Equilibrium Band-Structure View of Ultrafast Magnetization Dynamics — •Robert Carley[1,2], John Bowlan[1], Kristian Döbrich[2], Björn Frietsch[1,2], Martin Teichmann[1,2], Jan Wolter[1], and Martin Weinelt[1] — [1]Freie Universität Berlin, Germany — [2]Max-Born-Institut, Berlin, Germany

We present recent results from ultrafast laser-driven magnetization dynamics experiments on the rare-earth local-moment ferromagnet Gadolinium. Our experiment combines angle-resolved photoemission spectroscopy (ARPES) with the VUV photon energies and time resolution made possible by high-order harmonic generation to scrutinize the non-equilibrium band structure following excitation of the ferromagnet by a short infrared pulse. On the timescale of a few picoseconds, transient changes of the minority and majority components of the exchange-split valence band reveal significant insight into the underlying microscopic processes. Furthermore, linear magnetic dichroism in photoemission allows us to directly follow the magnetic response of the localized 4f electrons, from which the magnetic moment arises.

MA 50.54 Fri 10:30 Poster D

Spin motive force induced by moving vortex in magnetic nanostructures — •Ajay Gangwar[1], Hans G. Bauer[1], Matthias Noske[2], Markus Weigand[2], Hermann Stoll[2], Gisela Schütz[2], Georg Woltersdorf[1], and Christian H. Back[1] — [1]University of Regensburg, Regensburg, Germany — [2]Max Planck Institute for Intelligent Systems Stuttgart, Germany

Recently, voltage signals due to spin motive force (SMF) have been observed in magnetic elements with a moving magnetic vortex core [1]. However a moving vortex core also represents a change of the magnetic inductance and therefore also leads to a large electro motive force (EMF). An unambiguous separation of EMF and SMF signals is necessary for the interpretation of the SMF voltage. For this reason

we simultaneously measure the voltage signal and the position of the moving magnetic texture in a sub-micron permalloy (Py) disk with high temporal and spatial resolution in a scanning X-ray transmission microscope (STXM). In this way we determine directly the phase relation between the obtained voltage signals and the position of the vortex core with respect to the nanoscale voltage probes. This technique allows us to unambiguously separate contributions from EMF (due to the change of magnetic induction) and SMF (due to the moving magnetic texture). We separate EMF and SMF by performing measurements in various configurations and by reversing the vortex core polarity.

[1] K. Tanabe et al., Nature Communications 3, 845 (2012).

MA 50.55 Fri 10:30 Poster D

Dynamic vortex core reversal studied with micromagnetic simulations — •Hans G. Bauer, Georg Woltersdorf, and Christian H. Back — Universität, Regensburg, Germany

Thin discs of soft magnetic material can have non-trivial ground states of the magnetization. When the demagnetization energy forces the magnetization to lie in the plane of the disc, ground states of curling magnetization (vortex) exist with the magnetization in the middle pointing out-of-plane (vortex core). The ground state is degenerate with respect to the vortex core pointing either up or down (polarity) and the rotation sense of the in-plane magnetization (chirality).

While both are in principle capable of representing a bit in data storage we study two cases of polarity switching, where the vortex core polarity is reversed by a) a short rotating field pulse and b) a combination of sub-GHz and GHz excitations.

First we address the problem of the minimal time required to selectively switch the vortex core with short pulses. In the second study we investigate the threshold amplitude needed for switching at GHz-frequencies when the vortex core is already displaced from its equilibrium position by a low frequency excitation of the vortex, the so-called gyro-frequency. Both results are finally compared to the experimental findings in [1] and [2].

[1] M. Kammerer et al., Phys. Rev. B 86, 134426 (2012)
[2] M. Sproll et al. (to be published)

MA 50.56 Fri 10:30 Poster D

Collective Switching of Nanoparticles in Magnetic Arrays — •David Altwein, Elena Vedmedenko, Robert Wieser, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

Numerical simulations of the switching of ensembles of superparamagnetic nanoparticles in the framework of the Langevin Spin Dynamics as well as the path integral formalism are reported and compared with experimental results. The particles have been coupled via dipolar or RKKY interactions. In the case of a strong coupling a collective switching of particles has been observed. The continuous decrease of the coupling's strength leads to a continuous decrease in the coherency of the switching. The phase shift of the switching as a function of the interaction strength shows a gradual change similar to that of the order parameter in the second order phase transition. This dynamical phase transition is discussed and compared with existing theoretical models.

MA 50.57 Fri 10:30 Poster D

Synchronization between two pointcontact spin torque nano-oscillators — •Thomas Kendziorczyk and Tilmann Kuhn — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

It has been predicted theoretically and observed experimentally that a direct current traversing a magnetic multilayer exerts a spin torque on the magnetic system which can compensate the natural damping and lead to self-sustaining magnetic oscillations in the GHz range. Due to the easy frequency tunability of the spin torque nano-oscillators (STNOs) this effect has great potential for the construction of nanosized microwave generators. The main problem which has to be solved for future applications is the low output power of a single STNO. Some experiments have already been performed which show that it is possible to synchronize two STNOs. The output power for N synchronized STNOs could in principle scale with N^2. However, in order to construct larger arrays of STNOs a good knowledge about the interaction mechanism between them is indispensable. We will show by means of micromagnetic simulations, that there can exist several different synchronized states for two STNOs depending on the inter-contact distance and the initial phase difference of the free running oscillators. The multistability can be explained by the dispersion of the involved spin waves, which provide the main mechanism for the synchronization.

MA 50.58 Fri 10:30 Poster D

Temperature dependent spin transport and precession in non-local spin valves with transparent interfaces — •Björn Burkhardt[1], Nils Motzko[1], Piotr Laczkowski[2], and Laurent Vila[2] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz, 50099 Mainz, Germany — [2]Laboratoire Nanostructure et Magnetisme, CEA/INAC, 38054 Grenoble, France

In magnetic memory applications and spintronic devices a controlled switching of the magnetization is necessary. One possibility to manipulate the magnetization is to employ pure spin currents, for example in non-local spin valve (NLSV) configurations [1]. Here, the spin diffusion length and the spin flip time of the non-magnetic spin conduit material between two ferromagnetic wires play crucial roles for the efficiency of the resulting pure spin currents. We use aluminum and copper as non-magnetic spin conduits between two Permalloy stripes. Measuring the non-local spin signal as a function of temperature, we found a non-monotonous dependence and a maximum of the non-local signal and spin diffusion length at 23 K for Al and 38 K for Cu. These effects can be explained by different scattering mechanisms and probabilities at various temperatures. To determine this for Al-NLSVs we use Hanle measurements [2]. These show a small periodic effect caused by the spin precession which allowing us to deduce the spin diffusion parameters.

[1] D. Ilgaz et al., Phys. Rev. Lett. 105, 076601 (2010)
[2] G. Mihajlovic et al., Phys. Rev. Lett. 104, 237202 (2010)

MA 50.59 Fri 10:30 Poster D

Spin Hall and spin Nernst effect in dilute ternary alloys — •Katarina Tauber[1], Dmitry Fedorov[1], Martin Gradhand[2], and Ingrid Mertig[1,3] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]H.H. Wills Physics Laboratory, University of Bristol, United Kingdom — [3]Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

We present an ab initio study of the spin Hall as well as the spin Nernst effect. Both refer to the creation of a transverse spin current caused by an applied electric field or a temperature gradient, respectively. For the considered Cu-based dilute alloys, the dominant skew scattering mechanism was analysed for several pairs of impurities. We investigated the dependence of the transport properties of ternary alloys on the relative concentration of the two types of impurities. The efficiency of all systems with respect to the spin current generation is discussed in detail. All calculations are based on a fully relativistic Korringa-Kohn-Rostoker method and solution of a linearized Boltzmann equation, successfully applied to the SHE [1] and SNE [2] in binary alloys. The considered ternary alloys appeared to be well described by Matthiessen's rule. However, for the Hall resistivity deviations from Matthiessen's rule can have both signs in contrast to the longitudinal resistivity with only positive deviations.

[1] M. Gradhand et al., Phys. Rev. Lett. 104, 186403 (2010).
[2] K. Tauber et al., Phys. Rev. Lett. 109, 026601 (2012).

MA 50.60 Fri 10:30 Poster D

Magneto-resistance in electromigrated magnetic nanocontacts — •André Loescher[1], Mohamad-Assaad Mawass[1,5], Robert M. Reeve[1], Jakoba Heidler[2], Jan Rhensius[2,3], Laura J. Heyderman[2], Regina Hoffmann[4], and Mathias Kläui[1,2,3] — [1]Johannes Gutenberg-Universität Mainz, Germany — [2]Paul Scherrer Institut, Villigen, Switzerland — [3]Universität Konstanz, Germany — [4]Physikalisches Institut and DFG-Center for Functional Nanostructures, Karlsruhe Institute of Technology, Germany — [5]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany

Magnetotransport measurements on magnetic nanocontacts have been performed with the aim to understand the interactions between spin-polarized charge carriers and magnetization on the nanoscale. Here, we study the evolution of magnetoresistance (MR) in electromigrated ferromagnetic junctions obtained in clean ultra-high vacuum (UHV) conditions. While previously Permalloy ($Ni_{80}Fe_{20}$) nanocontacts with variable constriction width have been investigated, the fundamental behaviour of magnetization in such nanocontacts is not fully understood, with measurement artifacts often complicating the interpretation of results. *In-situ* controlled electromigration of notched half ring structures was performed in order to tailor the size of the contact.

The MR was measured as a function of the constriction width in order to study the magnetic properties and characterize the strength and extent of the domain wall pinning potential. Furthermore, the MR ratio at remanence is observed to reach 50% and exhibit a previously unobserved sign change in contacts that approach the atomic limit.

MA 50.61 Fri 10:30 Poster D

Spin Seebeck effect in FM/NM/NM hybrid structures — •Michael Schreier[1], Kathrin Ganzhorn[1], Mathias Weiler[1], Matthias Althammer[1,2], Sibylle Meyer[1], Rudolf Gross[1], and Sebastian T.B. Goennenwein[1] — [1]Walther-Meißner-Institut, Garching, Germany — [2]Univeristy of Alabama, Center for Materials for Information Technology MINT, Tuscaloosa, AL, USA

In the spin Seebeck effect thermally excited magnetic moments in a ferromagnet (FM) give rise to a pure spin current which is then detected in a normal metal (NM), usually platinum. Platinum, however, can be subject to a pronounced magnetic proximity effect, which induces a static magnetic polarization adjacent to the interface to the FM. This could eventually give rise to additional contributions by the anomalous Nernst effect in the longitudinal spin Seebeck geometry [1]. Therefore, we have conducted a series of measurements and simulations on YIG/Pt, YIG/Au/Pt, YIG/Cu/Pt, YIG/Au and YIG/Cu samples to verify whether recent spin Seebeck experiments have to be reevaluated on these terms. We find that contributions by the anomalous Nernst effect to the measured voltage signals [2] are much smaller, likely entirely negligible, than those from the spin Seebeck effect. Furthermore, the reported [1] inverse relation between the platinum film thickness and the spin Seebeck voltage can be explained by taking the spin diffusion in the NM into account. This work is supported by the DFG via SPP1538.

[1] S. Y. Huang et al., Phys. Rev. Lett. 109, 107204 (2012)
[2] M. Weiler et al., Phys. Rev. Lett. 108, 106602 (2012)

MA 50.62 Fri 10:30 Poster D

Efficient integration method for the intrinsic anomalous Hall conductivity — •Alexander Mook[1], Falko Pientka[1,2], Ingrid Mertig[1,3], and Peter Zahn[1,4] — [1]Institut für Physik, Martin-Luther-Universität, Von-Seckendorff-Platz 1, D-06120 Halle — [2]Fachbereich Physik, Freie Universität, D-14195 Berlin — [3]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle — [4]Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden

Haldane has already presented the expression of the intrinsic anomalous Hall conductivity as an integral over the Fermi surface as expected for Fermi-liquid theory [1] replacing the volume integral of the occupied states in the Brillouin zone.

We implemented both integration methods and applied them to a 4-band (sp^3) tight-binding Hamiltonian including both exchange splitting and spin-orbit coupling. Furthermore, we used an adaptive tetrahedral mesh refinement being based on the 8-tetrahedra-shortest-interior-edge method [2] to obtain convergence when integration over avoided crossings is necessary. Our investigations show that the results of both methods agree very well.

The adaptive integration method is applicable to advanced ab initio electronic structure schemes which provide besides the band energies also the Berry curvature.

[1] F. D. M. Haldane, *Phys. Rev. Lett.* **93**, 206602 (2004). [2] S. Zhang, *Houston J. Math.* **21** (3), 541-556 (1995).

MA 50.63 Fri 10:30 Poster D

Spin Nernst Angle: Definition and qualitative Estimation for Cu Alloys — •Peter Zahn and Sibylle Gemming — Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden, Germany

The spin Nernst effect describes the occurrence of a spin current perpendicular to an applied thermal gradient and the spin quantization axis in a non-magnetic material. To quantify the effect, the spin Nernst angle will be defined in a more general way than in ref. [1]. This allows for a clear separation of the transverse spin current into two opposite contributions proportional to the spin Hall angle and the spin Nernst angle, respectively. Qualitative trends for Cu alloys with 3d, 4d, and 5d defects extending a resonant scattering model by Fert and Levy [2] will be presented.

The work was supported by the Initiative and Networking Fund of the German Helmholtz Association, Helmholtz Virtual Institute MEMRIOX (VH-VI-442).

[1] K. Tauber et al., Phys. Rev. Lett. **109**, 026601 (2012)
[2] A. Fert and P.M. Levy, Phys. Rev. Lett. **106**, 157208 (2011)

MA 50.64 Fri 10:30 Poster D

Zinc ferrite, an oxide for spintronics? — •Michael Bonholzer, Kerstin Brachwitz, Annette Setzer, Pablo Esquinazi, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig

Bulk zinc ferrite is known as an antiferromagnetic insulator with normal spinel structure [1, 2]. But in thin films grown by pulsed laser deposition, semiconducting behaviour of the conductivity is found [1, 3]. The conductivity can be tuned over several orders of magnitude by changing the growth conditions [3]. Magnetism in thin films is also affected by growth conditions and shows different properties compared to bulk as well. Zinc ferrite thin films have a ferrimagnetic magnetisation curve with a high saturation magnetisation and a coercive field of about 10 mT at room temperature. Curie temperature is expected to be well above 800 K [2, 3]. The unexpected properties can be explained by disorder caused by oxygen vacancies [3]. Also theoretical calculations show the semiconducting and ferrimagnetic behaviour of slightly distorted zinc ferrite. They also predict a high spin polarisation [4]. The properties make zinc ferrite a promising material for spintronic applications. First results on magnetic tunnel junctions consisting of a zinc ferrite bottom electrode, a magnesium oxide barrier and a cobalt top electrode show a tunnel magnetoresistance up to 25%.

[1] A. Marcu et al., J. Appl. Phys. **102**, 023713 (2007)
[2] C.E. Rodríguez Torres et al., Phys. Rev. B **84**, 064404 (2011)
[3] M. Lorenz et al., Phys. Status Solidi RRL **5**, 438 (2011)
[4] S. Soliman et al., Phys. Rev. B **83**, 085205 (2011)

MA 50.65 Fri 10:30 Poster D

Quantitative analysis of the spin Hall magnetoresistance in-normal metal/ferromagnetic insulator hybrids — •F. Witek[1], S. Meyer[1], M. Althammer[2], S. Geprägs[1], M. Opel[1], R. Gross[1,3], A. Gupta[2], Y.-T. Chen[4], G.E.W. Bauer[4,5], H. Nakayama[5], E. Saitoh[5,6], and S.T.B. Goennenwein[1] — [1]Walther-Meißner-Institut, BAdW, Garching, Germany — [2]MINT Center, U. of Alabama, Tuscaloosa, USA — [3]Fakultät für Physik, TU München, Germany — [4]Kavli Institute of NanoScience, Delft, The Netherlands — [5]Institute for Materials Research, Tohoku U., Sendai, Japan — [6]The Advanced Science Research Center, JAEA, Tokai, Japan

Pure spin currents are a fascinating manifestation of spin physics in the solid state. We here report on a recently discovered magnetoresistance effect, arising from spin current flow across NM/FM interfaces. We observe this so-called spin Hall magnetoresistance (SMR) in $Pt/Y_3Fe_5O_{12}$ (Pt/YIG), Pt/nonferromagnetic metal/YIG, and Pt/Fe_3O_4 hybrid structures. The SMR effect stems from non-equilibrium spin transfer from the magnetic insulator into the Pt, in combination with spin Hall/inverse spin Hall effect. The SMR therefore characteristically depends on the orientation of the magnetization in the adjacent ferromagnet as observed in experiment. We show that the SMR is qualitatively different from the conventional anisotropic magnetoresistance effect arising in magnetic metals, and utilize the SMR to quantify the spin Hall angle and the spin diffusion length in the Pt layers. Financial support by the DFG via SPP 1538 SpinCAT and Nanoinitiative Munich (NIM) is gratefully acknowledged.

MA 50.66 Fri 10:30 Poster D

Determination of the magnetic depth profile of high-quality Fe_3O_4/ZnO heterostructures by polarized neutron reflectometry — •Michael Zapf[1], Ozan Kirilmaz[1], Sebastian Brück[1], Nina-Juliane Steinke[2], Nadezda Tarakina[3], Martin Kamp[3], Eberhard Goering[4], Michael Sing[1], and Ralph Claessen[1] — [1]Physikalisches Institut, Universität Würzburg, Germany — [2]Rutherford Appleton Laboratory, Chilton, UK — [3]Technische Physik, Universität Würzburg, Germany — [4]Max Planck Institute for Intelligent Systems, Stuttgart, Germany

Magnetite (Fe_3O_4) is one of the most promising materials for use as a spin injector into a semiconducting host. We demonstrate epitaxial growth of Fe_3O_4 films on the polar surfaces of ZnO single crystals. X-ray photoelectron spectroscopy evidences that the MBE-grown samples are phase-pure and nearly stoichiometric. The growth mechanism, the surface and film structure, the chemical profile and magnetic properties have been investigated in our previous publications.

To gain detailed information on the magnetic profile, polarized neutron reflectometry measurements were performed. Values for film thickness, roughness and magnetic moment were obtained from the reflectivity curves and checked against X-ray reflectometry, transmission electron microscopy and magnetometry data. A several nanome-

ter thick region of reduced magnetization in the strained Fe_3O_4 layers near the heterointerface could be resolved. Thereby the efficiency of spininjection into ZnO could be strongly affected.

MA 50.67 Fri 10:30 Poster D

Exploring spin-filter tunneling in magnetic oxide hybrids — •Bernardus Zijlstra[1], Christian Caspers[1], Sebastian Flade[1], Michael Voigt[1], Jürgen Schubert[2], Claus M. Schneider[1], and Martina Müller[1] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich — [2]Peter-Grünberg-Institut (PGI-9), Forschungszentrum Jülich

A key requirement for the development of spintronic devices is the ability to electrically generate highly spin-polarized currents. Magnetic oxides that posses a spin-filter functionality are an interesting route for achieving this. In order to study the spin-filter tunneling mechanism, EuO was utilized as a representative of this magnetic oxide class.

With regard to studying the influence of band structure on the spin-filtering effect, a model-system was realized. Single-crystalline, ultrathin layers of EuO(100) were grown on lattice-matched Sn-doped In_2O_3(100) and characterized by RHEED, XRD and TEM. Moreover, the electrical behavior in this system was studied by spin-filter tunneling experiments.

Furthermore, single-crystalline EuO(100) was epitaxially grown on Si(100) with the final aim of studying spin injection through a magnetic tunnel barrier into a semiconductor. Contrary to earlier predictions of thermodynamic stability of EuO on silicon, formation of an intermediate silicide-layer was observed. To overcome this problem, the silicon surface was passivated by an ultrathin SiO_x layer and magnetotransport experiments were performed on such EuO/SiO_x/Si heterostructures.

MA 50.68 Fri 10:30 Poster D

FMR measurements: Thickness dependence of YIG film investigated by spin pumping — •René Röser[1], Andreas Kehlberger[1], Gerhard Jakob[1], Benjamin Jungfleisch[2], Burkard Hillebrands[2], Ulrike Ritzmann[3], Denise Hinzke[3], Dong Hun Kim[4], Caroline Ross[4], Ulrich Nowak[3], and Mathias Kläui[1] — [1]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [2]Department of Physics, Institute of Technology Kaiserslautern, 67663 Kaiserslautern, Germany — [3]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [4]Department of Materials Science and Engineering, MIT, Cambridge, MA 02139, USA

The production method pulsed laser deposition (PLD) offers the opportunity to study high quality YIG ($Y_3Fe_5O_{12}$) films in the sub micrometer thickness regime (Yiyan Sun et al., Appl. Phys. Lett. 101, 152405 (2012)). Especially thin bilayer systems consisting of YIG coated with materials with high spin orbit coupling became focus of the general interest. These systems turned out to be an important mechanism for the generation of a spin current in nonmagnetic conductors by spin pumping (C.W. Sandweg et al., Phys. Rev. Lett. 106, 216601 (2011)). We present studies of a variety of YIG films produced by PLD. The films are characterized by the thickness, surface roughness and crystalline order. Furthermore the intrinsic magnetic properties are investigated by a SQUID and a Vector Network Analyzer-FMR setup. In order to determine the spin wave excitation spectrum in thin YIG films, which are coated with platinum, we compare films of thicknesses up to 300nm.

MA 50.69 Fri 10:30 Poster D

Nernst vs. spin-Seebeck effects in Py thin films — •M. Schmid[1], S. Srichandan[1], M. Vogel[1], C. Strunk[1], C. Back[1], D. Meier[2], T. Kuschel[2], J.M. Schmalhorst[2], and G. Reiss[2] — [1]1Physics department University of Regensburg, Regensburg, Germany — [2]Thin Films and Physics of Nanostructures, Department of Physics, University of Bielefeld, Germany

Magneto-thermal effects are investigated in Permalloy (Py) films deposited on different substrates (MgO and GaAs). The transverse voltage V_y is measured with attached Pt stripes on the Py. The measurements are taken with different in plane temperature gradients (along x) up to 50 K and an applied in plane magnetic field at various angles. The obtained signals can be identified as a combination of the anomalous (ANE) and the planar (PNE) Nernst effects. The PNE follows a $\cos(\Theta)\sin(\Theta)M\nabla T$ dependence, with M the magnetization, ∇T the temperature gradient and Θ being the angle between the two. The PNE voltage is of the order of μV which is consistent with the literature [1]. The ANE exhibits a $\cos(\Theta)$ relation with an amplitude of about 100 nV and is connected to an out of plane temperature gradient. Additionally, a small, but non-negligible contribution of the spin-Seebeck effect is considered but its magnitude is orders smaller than reported in the literature [2]. A COMSOL simulation of the temperature distribution supplements our interpretation. Finally, we studied Nernst effects in Py films deposited SiN membranes.

[1]Vu DinH Ky, Phys. Stat. Sol. 17, K207 (1966)
[2]K. Uchida, Nature 455, 778-781 (2008)

MA 50.70 Fri 10:30 Poster D

In search of spin caloric effects in thin permalloy films using different setups for transverse spin Seebeck effect measurements — •Timo Kuschel[1], Daniel Meier[1], Takashi Kikkawa[2], Ken-ichi Uchida[2], Eiji Saitoh[2], Jan-Michael Schmalhorst[1], and Günter Reiss[1] — [1]University of Bielefeld, Germany — [2]Tohoku University of Sendai, Japan

In spin caloritronics the spin Seebeck effect (SSE) (generation of a spin current by a temperature gradient) plays an important role. After the original observation in thin permalloy films on sapphire substrates in the transverse geometry (TSSE) in 2008 many scientific groups tried to measure the TSSE on different materials. Often an additional out-of-plane temperature gradient generates an anomalous Nernst effect (ANE) which contributes to the measured signal.
We built up a setup for TSSE measurements and investigated thin permalloy films on sapphire and MgO substrates. While our measurements reveal a symmetric contribution concerning the external magnetic field due to the anisotropic thermopower (planar Nernst effect), an additional asymmetric contribution due to the TSSE or ANE is not observed in most cases. For comparison we used the original setup in Japan and obtained different results for the same samples. An asymmetric contribution due to the TSSE or ANE is now contributing for nearly every sample. This inconsistency is discussed in the context of setup differences and probable out-of-plane temperature gradients.

MA 50.71 Fri 10:30 Poster D

Anisotropic magneto-thermopower and control of temperature gradients in (113) oriented (Ga,Mn)As thin films — •Mathias Frank[1], Sibylle Meyer[1], Lukas Dreher[2], Wladimir Schoch[3], Rudolf Gross[1,4], and Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany — [3]Institut für Quantenmaterie, Universität Ulm, Ulm, Germany — [4]Physik-Department, Technische Universität München, Garching, Germany

For caloritronic experiments, it is of crucial importance to control the direction and amplitude of temperature gradients within a given sample. We have implemented and compared different methods to apply and measure longitudinal and transverse temperature gradients in a (Ga,Mn)As thin film. We further studied the anisotropic magneto-thermopower (AMTP), i.e. the characteristic dependence of the thermopower with respect to the orientation of the magnetization vector. Our data show that the AMTP can be adequately modeled only if the symmetry of the (Ga,Mn)As crystal is explicitly taken into account. We quantitatively compare the AMTP data with the anisotropic magnetoresistance (AMR) data taken on the same (113) - oriented (Ga,Mn)As thin film and with corresponding model calculations. Moreover, we address the differences between the magnetoresistance and the magneto-thermopower coefficients. Financial support by DFG via SPP 1538 is gratefully acknowledged.

MA 50.72 Fri 10:30 Poster D

Dynamical heating of ferrimagnetic structures in a wide range of magnetic fields — •Thomas Langner, Vitaliy Vasyuchka, Benjamin Jungfleisch, Andrii Chumak, Alexander Serga, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Erwin-Schroedinger-Str. 56, 67663 Kaiserslautern, Germany

Precessing magnetic moments can generate heat due to the decay of the precessional motion and the following transfer of energy into the phonon system. We placed a polycrystalline disc of yttrium iron garnet (YIG) in an external magnetic field and excited it with high power microwaves. The temperature of the disc was monitored with an infrared camera. Beside large heating at the ferromagnetic resonance (FMR) we show an unexpected heat generation with applied microwave frequencies around 3.5 GHz for magnetic fields between 0 and 200 Oe far below the FMR. In spite of practically the same absorption of microwaves

the heating becomes smaller with higher magnetic field values in the mentioned range. The behavior can then be understood by resonant magnetic excitations of the grain structure inside the polycrystalline material. This assumption can be confirmed by a comparison to the behavior of a monocrystalline YIG structure and by an excitation of the polycrystalline sample by microwaves of higher frequencies.

Financial support by Deutsche Forschungsgemeinschaft within priority program SPP 1538 "Spin Caloric Transport" is gratefully acknowledged.

MA 50.73 Fri 10:30 Poster D

Structural and magnetic properties of $NiFe_2O_4$ thin films prepared by different deposition techniques — •Christoph Klewe[1], Timo Kuschel[1], Daniel Meier[1], Gerhard Götz[1], Liming Shen[2], Arunava Gupta[2], Karsten Küpper[3], Jan-Michael Schmalhorst[1], and Günter Reiss[1] — [1]Bielefeld University, Germany — [2]University of Alabama, Tuscaloosa, AL, USA — [3]University of Osnabrück, Germany

Recent advances in the field of spin caloritronics have urged the search for ferro- or ferrimagnetic, insulating materials in thin film form. One material which promises to be suitable for studies of the longitudinal Spin Seebeck effect is Nickelferrite ($NiFe_2O_4$). We fabricated $NiFe_2O_4$ thin films on $MgAl_2O_4$ (001) substrates by direct liquid injection chemical vapour deposition(DLI-CVD) and dc magnetron co-sputtering in a pure oxygen atmosphere. Stoichiometric measurements were performed using energy dispersive x-ray spectroscopy (EDX), x-ray fluorescence (XRF) and sputter x-ray photoelectron spectroscopy (XPS). Structural properties were investigated by x-ray diffraction analysis (XRD) and scanning electron microscopy (SEM). Magnetic properties were determined from magnetooptic Kerr effect (MOKE) and alternating gradient magnetometry (AGM) measurements. Temperature dependent measurements were carried out in order to investigate the resistivity and determine the bandgap. The results were compared to identify the best deposition technique and parameters with regard to the insulating properties of the ferromagnetic films.

MA 50.74 Fri 10:30 Poster D

Cooling Nanodevices by Spin Currents — •Jochen Brüggemann[1], Stephan Weiss[2], Peter Nalbach[1], and Michael Thorwart[1] — [1]1. Institut für theoretische Physik, Universität Hamburg, 20355 Hamburg, Deutschland — [2]Theoretische Physik, Universität Duisburg-Essen & CENIDE, 47048 Duisburg, Deutschland

In analogy to the demagnetization cooling for macroscopic devices, we aim to develop and analyze a magnetocaloric cooling cycle for nanodevices. For a proof of principle, a simple model consists of the following: First, an interacting quantum dot, which is tunnel coupled to ferromagnetic leads; second, dot electrons which can interact via exchange interaction with a localized impurity spin; and third, a Holstein phonon for the mechanical degrees of freedom. Using the real-time diagrammatic perturbation theory in lowest order in the hybridization of the leads, we determine the impurity spin dynamics as well as the mean energy of the mechanical oscillator as functions of the system parameters and the bias voltage. In agreement with previous findings, we reproduce an effective cooling of the impurity spin in the stationary limit. In the transient nonequilibrium regime, we realize a cooling cycle aiming at accumulating an increased ground state population of the phonon due to the cooling of the impurity spin as compared to the initial preparation.

MA 50.75 Fri 10:30 Poster D

Steady-state measurements of thermal effects in GaMnAs/ GaAs/Pt systems — •Nadezda Panarina[1], Ivan Soldatov[1], Christian Hess[1], Rudolf Schäfer[1], Sibylle Meyer[2], Sebastian Gönnenwein[2], Wolfgang Limmer[3], and Wladimir Schoch[3] — [1]IFW Dresden, Dresden, Germany — [2]WMI, Garching, Germany — [3]Universität Ulm, Ulm, Germany

The steady-state measurements were performed on the GaAs/GaMnAs/ Pt system, where the so-called spin Seebeck effect is claimed to exist. The main principle of the steady-state technique lies in attaining and controlling thermal equilibrium and stable thermal gradient along the sample, which provides enhanced accuracy of the experimental data. It was possible to detect the transverse electric signal on the Pt strips deposited at different distances to the heater. The behavior of the detected signal (sign and value) depended strongly on the experimental details, such as position of the heater on the sample (on top or side), the range of the magnetic field sweep (varying from tens up to hundreds of mT) and temperature of measurement. Moreover, the transverse voltage was registered directly on the GaMnAs film in the same run of the experiments. This fact questions the role of Pt layers in detecting the thermal-gradient-induced signal and suggests the transverse thermopower, or planar Nernst, origin of the magneto-electric effects observed in the thin ferromagnetic film of GaMnAs.

MA 50.76 Fri 10:30 Poster D

Spin wave mediated heating in a magnetic insulator — •Vitaliy I. Vasyuchka, Alexander A. Serga, Andrii V. Chumak, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

We present the results on spin wave mediated heating in films of a magnetic insulator using a thermography technique. The experiments were performed using a single-crystal yttrium iron garnet (YIG) film. We have found conditions when the direction of the heating of the sample can be controlled by an external magnetic field. In this case a large shift of the temperature maximum away from the excitation antenna of up to a few millimeters was observed. It was understood as a result of the interplay between the unidirectional heating and the diffusion of heat into the cold part of the YIG film. We found that the temperature maximum and its shift relative to the excitation antenna strongly depend on the speed of spin waves.

Financial support by the Deutsche Forschungsgemeinschaft (DFG) within Priority Program 1538 "Spin Caloric Transport" is gratefully acknowledged.

MA 50.77 Fri 10:30 Poster D

Ground state, static vortices, and dynamic excitations in magnon Bose-Einstein condensates — •Patryk Nowik-Boltyk[1], Oleksandr Dzyapko[1], Vladislav Demidov[1], Natasha Berloff[2], and Sergej O. Demokritov[1] — [1]Universität Münster; Institut für Angewandte Physik — [2]University of Cambridge, Department of Applied Mathematics and Theoretical Physics

Although the basic properties of magnon Bose-Einstein condensates have been extensively studied during the last 5 years, details of the ground state, topological defects and induced dynamics of the condensate have not been addressed so far. Here we present a detailed study of the ground state of the condensate and static vortices as well as the dynamics of the condensate by means of space- and time-resolved Brillouin Light Scattering spectroscopy. We show that the intrinsic degeneracy of the condensate results in formation of a non-uniform ground state demonstrating a standing-wave of the condensate density. We also experimentally observed static defects in the condensate in a form of quantized vortices. The study of induced dynamics was performed using spatially and temporary non uniform external magnetic fields. For relatively slow field pulses we observe a quasi-adiabatical accommodation of the condensate density at the place of the field. If we use very short and fast field pulses, travelling density waves can be observed. If the field is varied periodically in the megahertz frequency range, traveling density waves are also observed. The dispersion relation of the newly observed waves is determined.

MA 50.78 Fri 10:30 Poster D

Nonlinear emission of spin-wave caustics from an edge mode of a micro-structured $Co_2Mn_{0.6}Fe_{0.4}Si$ waveguide — •Thomas Sebastian[1,2], Philipp Pirro[1], Thomas Brächer[1,2], Takahide Kubota[3], Hiroshi Naganuma[4], Alexander A. Serga[1], Mikihiko Oogane[4], Yasuo Ando[4], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, 67663 Kaiserslautern, Germany — [3]WPI Advanced Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan — [4]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Sendai 980-8579, Japan

The low Gilbert damping of the Heusler compound $Co_2Mn_{0.6}Fe_{0.4}Si$ (CMFS) makes the material a promising candidate for the utilization in perspective *magnon-spintronic* devices [1].

We present the nonlinear emission of spin-wave caustics [2] from a localized edge mode [3] in a CMFS waveguide at twice and three times the excitation frequency observed by Brillouin light scattering microscopy. The propagation characteristics of these strongly directed beams are confirmed by analytic modeling using the anisotropic dispersion for spin waves in magnetic thin films.

We acknowledge support by the DFG Research Unit 1464 and the Strategic Japanese-German Joint Research from JST: ASPIMATT.

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MA 50.79 Fri 10:30 Poster D

Magnon temperature measurement: new insights into spin Seebeck effect — •Milan Agrawal[1], Vitaliy I. Vasyuchka[1], Alexander A. Serga[1], Alexy D. Karenowska[2], Gennadiy A. Melkov[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Kaiserslautern, 67663, Germany — [2]Department of Physics, University of Oxford, Oxford OX1 3PU, UK — [3]Faculty of Radiophysics, Taras Shevchenko National University of Kyiv, 03127 Kyiv, Ukraine

The study of magnon-phonon interaction is very important for the advancement of the emerging field of spin caloritronics [1]. The distribution of magnon and phonon temperatures in ferromagnets can explain the thermal spin-transport phenomena which have been observed electrically by measuring the induced inverse spin Hall voltage in normal metal placed over the ferromagnet [2-3]. Here, we report on the measurement of spatial distribution of magnon temperature in magnetic system imposed to a lateral thermal gradient by studying the variation of local magnetization. Our measurements reveal a strong correlation between magnons and phonons, and state that the contribution of magnons to the spin Seebeck effect in magnetic insulators is negligible or rather small. Furthermore, typical length scale of phonon-magnon interaction is calculated. Our results give new insights into the magnon contribution to the spin Seebeck effect.

[1] Bauer, G. E. W. & et al. Nature Mater. 11, 391-399 (2012)
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MA 50.80 Fri 10:30 Poster D

Heat-induced damping manipulation in YIG/Pt heterostructures — •Matthias Benjamin Jungfleisch[1], Toshu An[2], Kazuya Ando[2], Yosuke Kajiwara[2], Ken-ichi Uchida[2], Vitaliy I. Vasyuchka[1], Andrii V. Chumak[1], Alexander A. Serga[1], Eiji Saitoh[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — [2]Institute for Material Research, Tohoku University, Sendai 980-8577, Japan.

One of the main objectives in the field of magnon spintronics is the control and manipulation of magnetization relaxation and the generation of spin waves.

Here, we show the manipulation of spin-wave damping utilizing a temperature difference across the thickness of an yttrium iron garnet (YIG)/platinum (Pt) multi-structure. This temperature difference ΔT gives rise to the longitudinal spin Seebeck effect: an imbalance between the effective magnon and the effective electron temperatures causes a spin current across the YIG/Pt interface. Since the created spin current transfers spin angular momentum, a torque is exerted on the magnetization. Consequently, the magnetization precession is either enhanced or suppressed depending on the sign of ΔT. This damping variation can be expressed as a change of the ferromagnetic resonance linewidth ΔH_{FMR} that is measured by spin pumping in the adjacent Pt layer as well as by microwave reflection.

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MA 50.81 Fri 10:30 Poster D

Correlation of Inverse Spin Hall Effect to the crystal growth of magnetic films — •Philipp Fuhrmann, Evangelos Papaioannou, and Burkard Hillebrands — Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany

Spin transfer torque and spin pumping phenomena in magnetic hetero structures have attracted a lot of interest in the field of spintronics. Spin pumping and Inverse Spin Hall Effect (ISHE) in ferromagnetic / normal metal systems have been extensively investigated over the last years, covering dependencies on layer thickness and choice of material. However no systematic studies have been performed regarding the influence of the growth modes of the ferromagnetic / normal metal systems on spin pumping and ISHE.

In this work we present the correlation of crystal growth to ISHE. Structural properties of high quality epitaxial Fe films, covered with a Pt layer, are shown by Scanning Tunnel Microscopy and X-Ray Reflectivity. Characteristic roughness parameters are extracted by height-height correlation analysis. Magnetization properties are studied with the help of longitudinal Kerr effect. We show the dependence of ISHE on the crystal quality, and we correlate ISHE to surface roughness and magnetic anisotropies.

MA 50.82 Fri 10:30 Poster D

^{1}H-NMR in the heterometallic complex Mn_2Ni_3 — •Marco Günther[1], Liang Gong[1], Markus Brettschneider[1], Evgenia Vavilova[2], Vladislav Kataev[3], Animesh Das[4], Franc Meyer[4], and Hans-Henning Klauss[1] — [1]Institut für Festkörperphysik, TU Dresden — [2]Kazan Physical-Technical Institute — [3]Leibniz-Institute for Solid State and Materials Research IFW Dresden — [4]Institut für Inorganic Chemistry, Georg-August-University Göttingen

We studied the quasi-linear heterometallic complex Mn_2Ni_3, a recently synthesized single-molecule magnet by means of solid state proton NMR. The proton spectra is observed down to T=1.5 K where strong static hyperfine fields due to the $|S^z_{tot}$ =-7> ground state arise. The spectra is simulated with respect to the dipole summation of electronic moments at the local probe sites.

Proton T_1-relaxation rate probes the electronic dynamics in the paramagnetic regime down to the ground state formation within two orders of magnitude. For the lowest temperatures, we present our measurements of the field-depending relaxation experiments.