Magnetism Division
Fachverband Magnetismus (MA)

Michael Farle (Vors. FV MA)
Fakultät für Physik
Universität Duisburg-Essen
47057 Duisburg
fv-magnetismus-farle@uni-due.de

Gernot Güntherodt (Vors. AG MAG)
Physikalisches Institut II A
RWTH Aachen
52056 Aachen
gernot.guentherodt@physik.rwth-aachen.de

Overview of Invited Talks and Sessions

(Lecture Rooms: HSZ 04, HSZ 401, HSZ 403, BEY 118; Posters: P1 (Tuesday) and P2 (Friday))

General Meeting of the Magnetism Division (Fachverband Magnetismus)

Wednesday 18:15–19:30 HSZ 04
All members of the Magnetism Section are invited to participate!

Thyssen-Krupp Electrical Steel Dissertationspreis

Monday 12:30–14:00 HSZ 04
Four candidates will compete for the prize. Please attend!

Invited Talks

MA 11.1	Mon	15:00–15:30	BEY 118	**Design principles of Dirac fermions and Mott insulating states in (111) oriented perovskite superlattices** — •Rossitza Pentcheva
MA 20.1	Tue	15:00–15:30	BEY 118	**Manipulating the magnetic properties of single atoms on surfaces** — •Alexander Ako Khajetoorians
MA 20.2	Tue	15:30–16:00	BEY 118	**Spin Interaction of Atoms studied with Ultrafast STM** — •Sebastian Loth

PhD-Student Symposium "Magnon Plasmonics": Topical Talks (jointly with jDPG)

MA 13.1	Tue	9:30–10:15	HSZ 04	**Plasmons & Magnons: Collective excitations of charge and spin** — •Robert Stamps
MA 13.2	Tue	10:15–10:45	HSZ 04	**Nanomagnonics - reprogrammable wave control beyond plasmonics** — •Dirk Grundler
MA 13.5	Tue	11:30–12:00	HSZ 04	**Basic concepts of magneto-plasmonics illustrated with an exactly solvable system** — •Antonio García-Martín, Gaspar Armelles, Alfonso Cebollada, Maria U. Gonzalez
MA 13.8	Tue	13:30–14:00	HSZ 04	**Magnetoplasmonics with plasmon nanoantennas** — •Alexandre Dmitriev
MA 13.11	Tue	14:30–15:00	HSZ 04	**Ultrafast phenomena in magneto-plasmonic multilayer structures** — •Vasily Temnov

Symposium SYMO "Magnetic/Organic Interfaces and Molecular Magnetism"

SYMO 1.1	Mon	9:30–10:00	HSZ 02	**Molecular quantum spintronics with single-molecule magnets** — •Wolfgang Wernsdorfer
SYMO 1.2	Mon	10:00–10:30	HSZ 02	**EPR Studies of Rare-Earth Molecular Nanomagnets** — •Stephen Hill, Sanhita Ghosh, Dorsa Komijani, Salvador Cardona-Serra, Jose-Jaime Baldovi, Yan Duan, Alejandro Gaita-Arino, Eugenio Coronado

SYMO 1.3	Mon	10:45–11:15	HSZ 02	**On-surface magnetochemistry of spin-bearing metalorganic molecules** — •Peter M. Oppeneer, Kartick Tarafder, Ehesan Ali, Nirmalya Ballav, Christian Wäckerlin, Thomas A. Jung
SYMO 1.4	Mon	11:15–11:45	HSZ 02	**Interfacing single-molecule magnets with metals** — •Andrea Cornia, Valeria Lanzilotto, Luigi Malavolti, Matteo Mannini, Mauro Perfetti, Luca Rigamonti, Roberta Sessoli
SYMO 1.5	Mon	11:45–12:15	HSZ 02	**Linking magnetic molecules to themselves, to others and to surfaces** — •Richard Winpenny

Focus Session "New trends in Molecular Magnetism"

MA 8.1	Mon	15:00–15:30	HSZ 04	**Spin dynamics in Molecular Nanomagnets** — •Stefano Carretta
MA 8.2	Mon	15:30–16:00	HSZ 04	**Exchange interaction in lanthanides** — •Liviu Chibotaru, Liviu Ungur, Naoya Iwahara, Veaceslav Vieru
MA 8.3	Mon	16:00–16:30	HSZ 04	**Cool molecules** — •Marco Evangelisti
MA 8.4	Mon	16:30–17:00	HSZ 04	**Bulk and submonolayer studies of novel single-ion molecular magnets** — •Jan Dreiser
MA 8.5	Mon	17:00–17:30	HSZ 04	**When Organic Materials Interact with Ferromagnetic Surfaces: A First-Principles Perspective** — •Nicolae Atodiresei

Focus Session "Spin-Orbit Torque at Surfaces and Interfaces"

MA 31.1	Wed	15:00–15:30	BEY 118	**Magnetization switching and spin-orbit torques in AlOx/Co/Pt and MgO/CoFeB/Ta layers** — •Pietro Gambardella
MA 31.2	Wed	15:30–16:00	BEY 118	**Recent Theoretical Progress in Spin-orbit Torques** — •Aurelien Manchon
MA 31.3	Wed	16:00–16:30	BEY 118	**Domain-wall depinning governed by the spin Hall effect** — •Reinoud Lavrijsen, Bert Koopmans, Henk Swagten, Elena Mure, Jeroen Franken, Pascal Haazen
MA 31.4	Wed	16:45–17:15	BEY 118	**The Spin Hall Effect and Spin Orbit Torques in Ferromagnetic/Normal Metal Nanostructures** — •Robert Buhrman
MA 31.5	Wed	17:15–17:45	BEY 118	**Spin-orbit torques from first principles** — •Frank Freimuth

Focus Session "Chiral domain walls in ultrathin films"

MA 24.1	Wed	9:30–10:00	BEY 118	**On the rediscovery of the Dzyaloshinskii-Moriya interaction—A review** — •Matthias Bode
MA 24.2	Wed	10:00–10:30	BEY 118	**Chiral Magnetic Domain Wall Structure in Epitaxial Multilayers** — •Yizheng Wu, Gong Chen, Jie Zhu, Alpha T. N'Diaye, Tianping Ma, HeeYoung Kwon, Changyeon Won, Andreas. K. Schmid
MA 24.3	Wed	10:45–11:15	BEY 118	**'Dzyaloshinskii domain walls' in ultrathin magnetic films** — •André Thiaville, Stanislas Rohart, Emilie Jué, Olivier Boulle, Vincent Cros, Albert Fert, Stefania Pizzini, Jan Vogel
MA 24.4	Wed	11:15–11:45	BEY 118	**Current-driven dynamics of chiral ferromagentic domain walls** — •Geoffrey Beach
MA 24.5	Wed	11:45–12:15	BEY 118	**Phenomenology of current-induced spin-orbit torques** — •Kjetil M. D. Hals

Focus Session "Unconventional Spin Structures (jointly with DS)"

MA 39.1	Thu	9:30–10:00	BEY 118	**Topological Effects in Nanomagnetism - From Perpendicular Recording to Monopoles** — •Hans-Benjamin Braun
MA 39.2	Thu	10:00–10:30	BEY 118	**Topology and Origin of Effective Spin Meron Pairs in Ferromagnetic Multilayer Elements** — •Sebastian Wintz

MA 39.3	Thu	10:30–11:00	BEY 118	**Symmetry breaking in the formation of magnetic vortex states in a permalloy nanodisk** — •Peter Fischer, Mi-Young Im, Keisuke Yamada, Tomonori Sato, Shinya Kasai, Yoshinobu Nakatani, Teruo Ono
MA 39.4	Thu	11:15–11:45	BEY 118	**Commensurability and chaos in magnetic vortex oscillations** — •Joo-Von Kim, Sébastien Petit-Watelot, Antonio Ruotolo, Rubén Otxoa, Karim Bouzehouane, Julie Grollier, Arne Vansteenkiste, Ben Van de Wiele, Vincent Cros, Thibaut Devolder
MA 39.5	Thu	11:45–12:15	BEY 118	**Dynamic ordering of vortex cores in interacting mesomagnets** — •Valentyn Novosad

Sessions

MA 1.1–1.4	Sun	16:00–18:35	HSZ 403	**Tutorial: Energy materials**
MA 2.1–2.6	Mon	9:30–11:00	HSZ 401	**Magnetic Clusters**
MA 3.1–3.9	Mon	9:30–11:45	HSZ 403	**Spin Hall Effects**
MA 4.1–4.10	Mon	9:30–12:00	BEY 118	**Magnetic Heuslers, Half-metals and Oxides I (with TT)**
MA 5.1–5.11	Mon	9:30–12:30	POT 051	**Topological insulators: mostly structure and electronic structure (with HL/O/TT)**
MA 6.1–6.8	Mon	10:30–13:15	TRE Ma	**Focussed Session: Frontiers of Electronic Structure Theory - Non-equilibrium Phenomena at the Nano-scale (with O)**
MA 7	Mon	12:30–14:00	HSZ 04	**ThyssenKrupp Electrical Steel Dissertationspreis der AG Magnetismus**
MA 8.1–8.5	Mon	15:00–17:30	HSZ 04	**Focus Session: New trends in Molecular Magnetism (with O/TT)**
MA 9.1–9.11	Mon	15:00–18:00	HSZ 401	**Magnetic Nanoparticles**
MA 10.1–10.11	Mon	15:00–18:00	HSZ 403	**Spin-dependent Transport Phenomena**
MA 11.1–11.12	Mon	15:00–18:45	BEY 118	**Magnetic Heuslers, Half-metals and Oxides II (with TT)**
MA 12.1–12.8	Mon	15:45–17:45	POT 081	**Topological insulators: mostly interaction with magnetic fields (with HL/O/TT)**
MA 13.1–13.15	Tue	9:30–15:45	HSZ 04	**PhD Symposium: Magnon Plasmonics (with jDPG)**
MA 14.1–14.10	Tue	9:30–12:15	HSZ 401	**Bio- and Molecular Magnetism**
MA 15.1–15.14	Tue	9:30–13:15	HSZ 403	**Spin structures and Magnetic Phase Transitions**
MA 16.1–16.12	Tue	9:30–12:45	BEY 118	**Multiferroics I (jointly with DF, DS, KR, TT)**
MA 17.1–17.9	Tue	13:45–16:00	HSZ 401	**Spintronics (jointly with HL,TT)**
MA 18.1–18.7	Tue	14:00–15:45	HSZ 403	**Magnetic Coupling Phenomena**
MA 19.1–19.49	Tue	13:00–15:30	P1	**Poster I**
MA 20.1–20.2	Tue	15:00–16:00	BEY 118	**Magnetic Adatoms on Surfaces (with O)**
MA 21.1–21.13	Wed	9:30–13:00	HSZ 04	**Multiferroics II (jointly with DF, DS, KR, TT)**
MA 22.1–22.12	Wed	9:30–12:45	HSZ 401	**Magnetization Dynamics I**
MA 23.1–23.10	Wed	9:30–12:15	HSZ 403	**Micro- and Nanostructured Magnetic Materials**
MA 24.1–24.5	Wed	9:30–12:15	BEY 118	**Focus Session: Chiral domain walls in ultrathin films**
MA 25.1–25.10	Wed	9:30–12:15	POT 051	**Graphene: Transport (with DY/DS/O/TT)**
MA 26.1–26.7	Wed	9:30–11:15	POT 151	**Topological insulators: Theory (with HL/O/TT)**
MA 27.1–27.7	Wed	10:15–12:00	POT 006	**Spintronics 1 (with HL/TT)**
MA 28.1–28.10	Wed	15:00–17:45	HSZ 04	**Magnetic Materials I**
MA 29.1–29.12	Wed	15:00–18:15	HSZ 401	**Magnetization Dynamics II**
MA 30.1–30.11	Wed	15:00–18:00	HSZ 403	**Experimental methods and magnetic imaging**
MA 31.1–31.5	Wed	15:00–17:45	BEY 118	**Focus Session: Spin-Orbit Torque at Surfaces and Interfaces**
MA 32.1–32.1	Wed	15:00–15:45	GER 37	**Invited Talk - Heidemarie Schmidt (Joint Session with DF, HL, DS, KR)**
MA 33.1–33.6	Wed	15:00–16:30	POT 006	**Quantum information systems I (with HL/TT)**
MA 34.1–34.12	Wed	17:00–20:00	P1	**Posters: Graphene (with DY/DS/HL/O/TT)**
MA 35	Wed	18:15–19:45	HSZ 04	**Mitgliederversammlung des Fachverbandes Magnetismus (MA)**
MA 36.1–36.10	Thu	9:30–12:15	HSZ 04	**Spincaloric Transport II (jointly with TT)**
MA 37.1–37.10	Thu	9:30–12:15	HSZ 401	**Spin Torque and Spin Excitations I**
MA 38.1–38.10	Thu	9:30–12:15	HSZ 403	**Magnetic Materials II**
MA 39.1–39.6	Thu	9:30–12:45	BEY 118	**Focus Session: Unconventional Spin Structures (jointly with DS)**

MA 40.1–40.9	Thu	10:00–12:30	POT 081	**Graphene-like materials: Silicene, MoS_2 and relatives (with DY/DS/HL/O/TT)**
MA 41.1–41.9	Thu	10:00–12:15	POT 151	**Spintronics 2 (with HL/TT)**
MA 42.1–42.12	Thu	15:00–18:15	HSZ 04	**Magnetic Materials III**
MA 43.1–43.12	Thu	15:00–18:15	HSZ 401	**Magnetization Dynamics III**
MA 44.1–44.6	Thu	15:00–16:30	HSZ 403	**Spin Torque and Spin Excitations II**
MA 45.1–45.13	Thu	15:00–18:30	BEY 118	**Spin Structures at Surfaces and in thin films I (Skyrmions)**
MA 46.1–46.11	Thu	15:00–18:00	POT 081	**Graphene: Spintronics, transistors, and sensors (with DY/DS/HL/O/TT)**
MA 47.1–47.8	Thu	16:45–18:45	HSZ 403	**Spincaloric Transport I (jointly with TT)**
MA 48.1–48.7	Thu	17:00–20:00	P1	**Poster: Spintronics (with TT)**
MA 49.1–49.12	Thu	17:00–20:00	P1	**Poster: Topological insulators (with O,TT)**
MA 50.1–50.9	Fri	9:30–12:00	HSZ 04	**Topological Insulators (jointly with DS,HL,O,TT)**
MA 51.1–51.10	Fri	9:30–12:00	HSZ 401	**Electron Theory of Magnetism**
MA 52.1–52.8	Fri	9:30–11:30	HSZ 403	**Magnetic Materials IV**
MA 53.1–53.10	Fri	9:30–12:00	BEY 118	**Spin Structures at Surfaces and in thin films II**
MA 54.1–54.6	Fri	9:30–11:00	POT 081	**Graphene: Bi- and multi-layers (with DY/DS/HL/O/TT)**
MA 55.1–55.113	Fri	10:30–13:30	P2	**Poster II**
MA 56.1–56.7	Fri	11:15–13:00	POT 081	**Graphene: Interaction with the substrate (with DY/DS/O/TT)**

MA 1: Tutorial: Energy materials

This tutorial introduces basic physical concepts underlying the microscopic working principles of a broad and diverse range of energy materials ranging from organic solar cells to strong magnets for wind turbines. Leading scientists from various different disciplines – both from academia and industry – will give an exciting overview of the state-of-the art in their specific field of expertise. The topics to be covered include: Electrochemical energy storage and battery research, superstrong magnets and magnetocalorics, dye-sensitized solar cells from the Graetzel cell to hybrid inorganic-organic perovskites, and solar water splitting. We also refer to the parallelly running tutorial on thermoelectricity. All talks are specifically prepared for a broad audience.

Organized by Erich Runge, TU Ilmenau, and Christoph Lienau, Carl von Ossietzky Universität Oldenburg, on behalf of the Semiconductor Physics Division jointly with the Magnetism Division.

Time: Sunday 16:00–18:35 Location: HSZ 403

Invited Talk MA 1.1 Sun 16:00 HSZ 403
Von Lithium zu Lithium-Ionen-Batterien und zurück — •Martin Winter — WWU Münster, Deutschland

Invited Talk MA 1.2 Sun 16:35 HSZ 403
Magnetic materials for green energy applications — •Oliver Gutfleisch — TU Darmstadt, Material Science, Functional Materials — Fraunhofer Project Group Materials Recycling and Resource Strategy IWKS

Due to their ubiquity, magnetic materials play an important role in improving the efficiency and performance of devices in electric power generation, conversion and transportation 1. Permanent magnets are essential components in motors and generators of hybrid and electric cars, wind turbines, etc. Magnetocaloric materials could be the basis for a solid state energy efficient cooling technique alternative to compressor based refrigeration. Any improvements in magnetic materials will have a significant impact in these areas, on par with many *hot* energy materials efforts (e.g. hydrogen storage, batteries, thermoelectrics, etc.).

The talk focuses on rare earth and rare earth free permanent magnet and magnetocaloric materials with an emphasis on their optimization for energy and resource efficiency in terms of the usage of critical elements. The synthesis, characterization, and property evaluation of the materials will be examined briefly having in mind their critical micromagnetic length scales and phase transition characteristics.

Coffee break (10 min.)

Invited Talk MA 1.3 Sun 17:20 HSZ 403
Recent developments of dye sensitized and mesoscopic solar cells — •Toby Meyer — Solaronix SA, Aubonne, Switzerland

The latest results on the Dye Sensitized Solar Cell developments at Solaronix are presented in the international context, both scientifically and economically. Examples include the first application in a 250 m^2 vertical façade at the Swisstech Convention Center (EPFL, Lausanne). Furthermore, we discuss the rapid progress in perovskite-based photovoltaics and show results on Solaronix's novel “perovskite” solid-state mesoscopic solar cells.

Invited Talk MA 1.4 Sun 17:55 HSZ 403
Perspectives of an artificial leaf based on inorganic semiconductors for water splitting: Device structure, interface engineering, catalytic demands — •Wolfram Jaegermann — TU Darmstadt, Instiute of Materials Science, Jovanka-Bontschits-Str. 2, D-64287 Darmstadt

For an effective conversion of solar energy to a chemical fuel a number of elementary processes as well as their coupling to each other must be optimized without severe losses in the number and the chemical potential of the originally generated electron-hole pairs. Light absorption coupled to efficient charge carrier generation and separation may be realized by thin film semiconductor devices - preferentially tandem cells - which may provide broad band quantum efficiencies close to 1. Alternatively, Janus type photocatalysts may be chosen which favour vectorial electron-hole pair transport into opposite directions. Subsequently, H2 (or HC-fuels) and O2 from H2O (and CO2) must be formed by electron and hole transfer reactions with minimized loss of chemical potential. This will only be possible if the involved charge transfer steps are coupled to selective multi electron transfer catalysts. Technologically feasible solutions seem to be possible for water splitting and H2-generation, as we will show with a number of investigations performed recently combining electrochemical investigations with surface science approaches.

Closing remarks

MA 2: Magnetic Clusters

Time: Monday 9:30–11:00 Location: HSZ 401

MA 2.1 Mon 9:30 HSZ 401
Coordination-driven magnetic-to-nonmagnetic transition in manganese doped silicon clusters — Vicente Zamudio-Bayer[1], •Linn Leppert[2], Konstantin Hirsch[1,3], Andreas Langenberg[1,3], Jochen Rittmann[1,3], Markus Kossick[1,3], Marlene Vogel[1,3], Robert Richter[3], Akira Terasaki[4], Thomas Möller[3], Bernd von Issendorff[5], Stephan Kümmel[2], and Tobias Lau[1] — [1]Institut für Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany — [2]Theoretical Physics IV, University of Bayreuth, Germany — [3]Institut für Optik und Atomare Physik, Technische Universität Berlin, Germany — [4]Cluster Research Laboratory, Toyota Technological Institute, Futamata, Ichikawa, Chiba, Japan — [5]Fakultät für Physik, Universität Freiburg, Germany

Using x-ray magnetic circular dichroism spectroscopy and non-empirical density functional theory we analyze the electronic, magnetic, and structural properties of manganese-doped silicon clusters. We find a correlation of the magnetic moment with the manganese coordination number and nearest-neighbor distance that indicates that high-spin states in manganese-doped silicon could be stabilized by an appropriate lattice expansion. We further discuss the necessity to correct for self-interaction errors in the underlying density functional approximation in order to predict the magnetic-to-nonmagnetic transition in accordance with experiment.

MA 2.2 Mon 9:45 HSZ 401
Laser control of ultrafast spin dynamics on homonuclear two- and three-magnetic-center clusters — •Wei Jin[1], Chun Li[2], Georgios Lefkidis[1], and Wolfgang Hübner[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Box 3049, 67653 Kaiserslautern, Germany — [2]School of Mechanics, Civil Engineering and Architecture, Northwestern Polytechnical University, Xi'an 710072, China

We present a fully *ab initio* theory for coherent laser-induced ultrafast spin manipulation on homonuclear two- and three-magnetic-center clusters.

For the homodinuclear magnetic clusters (FeOFe, FeOOFe, NiONi and NiOONi) with strong spin localizations induced by the bridging atoms, various spin flip and transfer scenarios are achieved. Out of the four clusters, the Fe-containing ones are more promising for logic operations, and this is consistent with the findings in Ref.[1].

In the pursuit of additional functionality motivated by Ref. [2] about the Co dimer, for the extended cluster Co_3^+CO we achieve a counterclockwise cycle of spin transfer driven by three sequential laser pulses. The whole process completes within 1.2 ps, which is much faster than any conventional device. Based on this striking functionality a cyclic SHIFT register is proposed as a future application. In the strive for better magnetization dynamics control, the results on these prototypic systems strongly indicate their great potential in spintronic devices.

[1] C. Li *et al.*, Phys. Rev. B **84**, 054415 (2011).
[2] C. Li *et al.*, J. Magn. Magn. Mater. **324**, 4024 (2012)

MA 2.3 Mon 10:00 HSZ 401

The Anderson Impurity Model in Finite Systems: A Study of $CrAu_n^+$ Clusters — •Konstantin Hirsch[1], Vicente Zamudio-Bayer[1], Andreas Langenberg[1], Markus Niemeyer[1], Bruno Langbehn[2], Thomas Möller[2], Akira Terasaki[3], Bernd von Issendorff[4], and Julian Tobias Lau[1] — [1]Institut für Methoden und Instrumentierung der Forschung mit Synchrotronstrahlung, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Straße 15, 12489 Berlin, Germany — [2]Institut für Optik und Atomare Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [3]Cluster Research Laboratory, Toyota Technological Institute, 717-86 Futamata, Ichikawa, Chiba 272-0001, Japan — [4]Fakultät für Physik, Universität Freiburg, Stefan-Meier-Straße 21, 79104 Freiburg, Germany

The Anderson impurity model (AIM) describes the interaction of a magnetic impurity with the continuous density of states of a nonmagnetic host. It gives a criterium for the magnetic to nonmagnetic transition depending on two parameters: the onsite Coulomb repulsion U_0 and the hybridization strength Γ. Here we discuss the validity of the AIM in a finite host material featuring a highly discretized density of states by applying XMCD spectroscopy to size-selected $CrAu_n^+$ clusters and studying the AIM within a tight binding approach.

MA 2.4 Mon 10:15 HSZ 401

***Ab initio* thermodynamics and heat nanoengines on the magnetic Ni_2 dimer** — •Wolfgang Hübner, Chuanding Dong, Debapriya Chaudhuri, and Georgios Lefkidis — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

We use the highly correlated excited electronic states of Ni_2, calculated with the symmetry-adapted-cluster configuration-interaction method, to develop thermodynamic processes and build heat engines with molecular magnets. Identifying the work of a thermodynamic process with the energy shift of the electronic- and spin levels, and the heat exchange with their population change [1] we derive an isobaric process [2] and build a Diesel and an Otto nanoengine, as well as a novel engine for which a laser pulse substitutes for the hot bath.

The many internal degrees of freedom and the nonthermal effects allow crossings of adiabatic processes in a $P-V$ diagram. We analyze the efficiency of the nanoengines and find a signifficant possible enhancement connected to the quantum nature, the spin and the heat capacity of Ni_2, as well as to the zero-field splitting of the triplet states. These new concepts connect spin dynamics with quantum thermodynamics and suggest new ways of designing effective magnetic heat-engines.
(In collaboration with J. Berakdar and L. Chotorlishvili, Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany.)

[1] M. O. Scully, Phys. Rev. Lett. **88**, 050602 (2002)
[2] C. D. Dong, G. Lefkidis and W. Hübner, J. Supercond. Nov. Magn. **26**, 1589 (2013)

MA 2.5 Mon 10:30 HSZ 401

Magnetism of sp-impurity-decorated grain boundaries and surfaces — Monika Vsianska[1,2,3], Hana Vemolova[3], and •Mojmir Sob[1,2,3] — [1]Central European Institute of Technology, CEITEC MU, Masaryk University, Brno, Czech Republic — [2]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic — [3]Department of Chemistry, Faculty of Science, Masaryk University, Brno, Czech Republic

We present a systematic ab initio study of segregation of 12 nonmagnetic sp-impurities (Al, Si, P, S, Ga, Ge, As, Se, In, Sn, Sb and Te) at $\Sigma 5(210)$ grain boundary (GB) and (210) free surface (FS) in fcc ferromagnetic cobalt and nickel and analyze their effect on structure, magnetic and mechanical properties. We determine preferred segregation sites at the $\Sigma 5(210)$ GB for the sp-impurities studied, their segregation enthalpies and strengthening/embrittling energies. In nickel, most of the above impurities nearly kill or substantially reduce the magnetic moments at the FS and, when segregating interstitially (i.e. Si, P, S, Ge, As, Se), also at the GB so that they provide atomically thin magnetically dead layers which may be very desirable in spintronics. Reduction of magnetic moments at the $\Sigma 5(210)$ GB in fcc ferromagnetic cobalt is, in absolute values, very similar to that in nickel. However, as the magnetic moment in bulk cobalt is higher, we do not observe magnetically dead layers here. It turns out that by focused impurity segregation we can generate atomically thin magnetic layers with tailored magnetization, which can contribute to a new development of technologically important materials.

MA 2.6 Mon 10:45 HSZ 401

Tuning the magnetic anisotropy of a single nanostructure by perimetric decoration — •Marco Corbetta[1], Soo-hyon Phark[1], Jeison Antonio Fischer[1,2], Safia Ouazi[1], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle (Saale), Germany — [2]Laboratório de Filmes Finos e Superfícies, Departamento de Física, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

We investigate individual Fe-decorated bilayer high Co islands on Cu(111) by spin-polarized STM in magnetic fields. Fe decorates the Co core by a few nm wide bilayer rim. This decoration induces larger switching fields Hsw of the Co cores as compared to those of pure Co islands of the same size [1,2]. The quantitative analysis of the island size dependence of the switching field reveals that all Co atoms of the Co core contribute to the magnetic anisotropy with an average value of 0.115 meV/atom. This is 22% less than we previously reported for pure Co islands [2]. On the basis of spatially resolved measurements of the differential conductance, we ascribe this change of magnetic anisotropy to the modification of the electronic and atomic structure of the Co core due to Fe-decoration. Our spectroscopy data indicate that structural relaxations of the Co core of Fe-decorated Co islands are negligible as compared to pure Co islands, and this might be an important aspect to understand the reduced magnetic anisotropy. The Fe rim does not show a net magnetic moment, as checked by SP-STM in magnetic fields. [1] H. Oka et al., Science 327, 843 (2010). [2] S. Ouazi et al. Phys. Rev. Lett. 108, 107206 (2012).

MA 3: Spin Hall Effects

Time: Monday 9:30–11:45 Location: HSZ 403

MA 3.1 Mon 9:30 HSZ 403

YIG thickness dependence of spin pumping in YIG/Pt heterostructures — •Viktor Lauer[1], Matthias Benjamin Jungfleisch[1], Andrii Chumak[1], Andreas Kehlberger[2], Dong Hun Kim[3], Mehmet Cengiz Onbasli[3], Caroline Ross[3], Mathias Kläui[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute of Physics, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [3]Department of Materials Science and Engineering, MIT, Cambridge, MA 02139, USA

The transport and processing of spin information via magnons, as well as their generation and detection are at the heart of magnon spintronics. A very convenient method to detect magnon currents electrically is the combination of spin pumping and the inverse spin Hall effect (ISHE). In our studies the YIG thickness dependence of the spin-pumping effect in YIG/Pt structures was investigated in the nanometer range ($20-300$ nm YIG films), which is shorter then the exchange correlation length. The observed increase of the ISHE-voltage with increasing film thickness is compared to the theoretically expected behavior. The effective damping parameter of the YIG/Pt samples is found to be enhanced with decreasing film thickness. The investigated samples exhibit a spin mixing conductance of $g = (7.43 \pm 0.36) \times 10^{18}$ m^{-2} and a spin Hall angle of $\theta_{\mathrm{ISHE}} = 0.009 \pm 0.001$.

Support by the DFG within the project CH 1037/1-1 is gratefully acknowledged.

MA 3.2 Mon 9:45 HSZ 403

Temperature dependence of the spin Hall magnetoresistance in YIG / Pt hybrids — •Sibylle Meyer[1], Matthias Althammer[1], Stephan Geprägs[1], Matthias Opel[1], Rudolf Gross[1,2], and Sebastian T. B. Goennenwein[1] — [1]Walther - Meißner - Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik - Department, Technische Universität München, 85748 Garching, Germany

The generation and detection of pure spin currents represents a new paradigm for spin electronics. Within the last two years, the spin Hall magnetoresistance (SMR), a novel type of magnetoresistance based on the interplay between spin and charge transport in ferromagnetic insulator/normal metal hybrids, has become a powerful tool to access the spin transport properties of normal metals. Here we study the temperature dependence of the SMR in $Y_3Fe_5O_{12}$/Pt hybrid structures via magnetization orientation dependent magnetoresistance measurements. Our experiments show that the SMR amplitude decreases with decreasing temperature, which can be modeled in terms of a spin Hall angle in Pt decreasing from 0.11 at room temperature to 0.075 at 10 K, while the spin diffusion length and the spin mixing conductance of the ferrimagnetic insulator/normal metal interface remain almost constant.

Financial support by the Deutsche Forschungsgemeinschaft via SPP 1538 (project no. GO 944/4) and the German Excellence Initiative via the "Nanosystems Initiative Munich (NIM)" is gratefully acknowledged.

MA 3.3 Mon 10:00 HSZ 403

Spin-pumping induced inverse spin Hall effect at Fe/Pt interface: the influence of Pt thickness — •Evangelos Papaioannou, Viktor Lauer, Thomas Brächer, Philipp Pirro, and Burkard Hillebrands — Fachbereich Physik, Technische Universität Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany

The spin-pumping effect allows for the injection of a spin current from a ferromagnetic (FM) layer into an attached non-magnetic metal (NM) layer. [1] This spin current is subsequently transformed into a charge current by the inverse spin Hall effect (ISHE). Here, we examine the role of Pt thickness on the spin-pumping induced inverse spin Hall effect in Fe/Pt bilayers. Pt is grown epitaxially on top of Fe in order to maximize the ISHE efficiency [2]. The morphology of the Fe/Pt interface influences the effective spin mixing conductance. In magnetic field dependent measurements, the presence of a strong magnetic anisotropy gives rise to two distinct inverse spin Hall effect voltage peaks. The Pt thickness dependence on the ISHE-voltage from spin pumping is discussed with respect to proximity effects that can appear at the Fe/Pt interface.

[1] Y. Tserkovnyak, A. Brataas, and G. Bauer, Phys. Rev. Lett. 88, 117601 (2002). [2] E. Th. Papaioannou, P. Fuhrmann, M. B. Jungfleisch, T. Brächer, P. Pirro, V. Lauer, J. Lösch, and B. Hillebrands, Applied Physics Letters 103, 162401 (2013).

MA 3.4 Mon 10:15 HSZ 403

Colossal spin Hall effect in ultrathin noble metal films — •Christian Herschbach[1], Dmitry Fedorov[1], Martin Gradhand[2], and Ingrid Mertig[3,1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]H. H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, United Kingdom — [3]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany

The application of the spin Hall effect (SHE) in spintronics devices requires materials with a large spin Hall angle (SHA). This quantity describes the conversion efficiency from a charge current into a spin current. Recently, Niimi et al. [1] measured a large SHA ($\sim 20\%$) in thin film Cu(Bi) alloys. Such a giant SHE was predicted by *ab initio* calculations of the skew-scattering mechanism in bulk Cu with substitutional Bi impurities [2]. We extended the method to the film geometry and showed the SHE to be significantly increased in one monolayer (ML) noble metal films with Pt impurities with respect to related bulk systems [3].

Here, we resume our study and show that Bi impurities in 1ML noble metal films can generate a SHA of up to 80% caused by skew scattering. This *colossal* SHE can be attributed to scattering at relativistic $p_{1/2}$ impurity states.

[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 3.5 Mon 10:30 HSZ 403

Phase shift model for the spin Hall effect in dilute metal alloys — •Dmitry Fedorov[1], Christian Herschbach[1], Annika Johansson[2], Martin Gradhand[3], Kristina Chadova[4], Diemo Ködderitzsch[4], Hubert Ebert[4], and Ingrid Mertig[2,1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany — [3]University of Bristol, Bristol, United Kingdom — [4]Ludwig-Maximilians University, Munich, Germany

A renewed interest to the resonant scattering model, derived originally for the description of the anomalous Hall effect, was initiated by Fert and Levy [1]. They considered it for the spin Hall effect in dilute metal alloys. Expressed initially for resonant d scatterers in terms of nonrelativistic phase shifts with a perturbative treatment of spin-orbit coupling (SOC), their model was reformulated later for strong p scatterers using relativistic phase shifts [2].

We developed [3,4] an extension of the relativistic and nonrelativistic resonant scattering model to arbitrary impurity atoms for the skew-scattering mechanism. Despite the generalization, a successful application of the model is restricted to dilute alloys based on host crystals with weak SOC and a free-electron like Fermi surface. This is illustrated by a comparison between the model and our first-principles calculations.

[1] A. Fert and P.M. Levy, PRL **106**, 157208 (2011); [2] Y. Niimi *et al.*, PRL **109**, 156602 (2012); [3] D.V. Fedorov *et al.*, PRB **88**, 085116 (2013); [4] C. Herschbach *et al.*, PRB **88**, 205102 (2013).

MA 3.6 Mon 10:45 HSZ 403

Phase-sensitive detection of both inductive and non-inductive ac voltages in ferromagnetic resonance — •Mathias Weiler, Justin M. Shaw, Hans T. Nembach, Martin A. Schoen, Carl T. Boone, and Thomas J. Silva — Electromagnetics Division, National Institute of Standards and Technology, Boulder, CO 80305

Spin pumping causes significant damping in ultrathin ferromagnetic/normal metal (NM) multilayers via spin-current generation of both dc and ac character in the NM system. While the nonlinear dc component has been investigated in detail by utilization of the inverse spin Hall effect (iSHE) in NMs, much less is known about the linear ac component that is presumably much larger in the small-excitation limit. We measured generated ac voltages in a wide variety of Permalloy/NM multilayers via vector-network-analyzer ferromagnetic resonance. We employ a custom, impedance-matched, broadband microwave coupler that features a ferromagnetic thin film reference resonator to accurately compare ac voltage amplitudes and phases between varieties of multilayers. We find that inductive signals are major contributors in all investigated samples. It is only by comparison of the phase and amplitude of the recorded ac voltages between multiple samples that we can extract the non-inductive contributions due to spin-currents. Voltages due to the ac iSHE in Py(10nm)/Pt(5nm) bilayers are of the same order of magnitude as inductive signals, in agreement with recent theoretical predictions.

M.W. acknowledges financial support by the German Academic Exchange Service (DAAD).

MA 3.7 Mon 11:00 HSZ 403

Experimental observation of a large ac-spin Hall effect — •Dahai Wei[1], Martin Obstbaum[1], Christian Back[1], and Georg Woltersdorf[1,2] — [1]Universität Regensburg, 93053 Regensburg, Germany — [2]Martin-Luth-Universität Halle, 06120 Halle, Germany

Spin pumping is the most popular approach to inject pure spin currents into various classes of nonmagnetic materials. The polarization direction of the injected spin currents is time dependent and contains only a very small dc-component [1]. This dc-component has been intensely studied in recent years. However in contrast, the two orders of magnitude larger ac-component has escaped experimental detection so far. Here we show that the large ac-component of the spin currents can be detected very efficiently using the inverse spin Hall effect (ISHE) leading to signals one order of magnitude larger than the conventional dc-ISHE measured on the same device. The spectral shape, angular dependence, power scaling behavior and absolute magnitude of the signals are in line with spin pumping and ISHE theory. Our results demonstrate that FM-NM junctions are very efficient sources of pure spin currents in the GHz frequency range.

[1] H. Jiao and G. E. Bauer, Phys. Rev. Lett., 110, 217602 (2013)

MA 3.8 Mon 11:15 HSZ 403

Experimental test of the spin mixing interface conductance concept — •Michael Schreier[1], Mathias Weiler[1], Matthias Althammer[1], Johannes Lotze[1], Matthias Pernpeintner[1], Sibylle Meyer[1], Hans Huebl[1], Rudolf Gross[1,2], Akashdeep Kamra[1,3], Jiang Xiao[4], Yan-Ting Chen[3], HuJun Jiao[3], Gerrit E. W. Bauer[3,5], and Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, DE — [2]Physik-Department, TU München, DE — [3]Kavli Institute of Nanoscience, Delft University of Technology, NL — [4]Department of Physics and State Key Laboratory of Surface Physics, Fudan University, CHN — [5]Institute of Materials Research and WPI-AIMR, Tohoku University, JP

Spin pumping (SP), spin Hall magnetoresistance (SMR) and the spin Seebeck effect (SSE) originate from spin transfer across the interface between a ferromagnet and a normal metal. The spin mixing conductance $g^{\uparrow\downarrow}$ in particular determines the rate by which spin accumulation on one side of the interface can relax to the other. Until now, however, a comprehensive, quantitative experimental test of the spin mixing interface conductance concept has been missing. Here, we present an in-depth analysis and experimental study of SP, SMR and SSE experiments conducted on a series of YIG/Pt samples from which we extract the relevant spin transport parameters (spin diffusion length, spin Hall angle and $g^{\uparrow\downarrow}$). Our findings strongly support the spin mixing interface conductance concept, i.e. the purely spintronic nature of all three effects [Weiler *et al.*, Phys. Rev. Lett. 111, 176601 (2013)].

MA 3.9 Mon 11:30 HSZ 403

Spin Hall and spin Nernst effect in 5d transition-metal thin films — •N. H. Long, P. Mavropoulos, B. Zimmermann, D. S. G. Bauer, S. Blügel, and Y. Mokrousov — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Spin Hall effect (SHE), where a transverse spin current is created in a nonmagnetic metal by an applied electrical field has developed into one of the most effective ways for spin-manipulation in nano-devices. In the nonmagnetic transition-metal alloys, one important contribution to the SHE is the skew-scattering due to impurities. A similar phenomenon, namely, the spin Nernst effect (SNE), has also been theoretically predicted and studied during the past years. Instead of applying an electric field, a transverse spin current can be produced by an applied temperature gradient via the SNE. Using our newly developed relativistic full-potential KKR Green function method, in this work we investigate the extrinsic SHE and SNE in 5d transition-metal thin films caused by the skew-scattering off adatom impurities. The conductivity tensor is calculated in terms of the Boltzmann equation at the dilute impurity concentration. The analysis is concentrated on the role played by the electronic structure of thin films as well as the surface states on the SHE and SNE. The calculated results allow the prediction of the emergence of large spin Hall as well as spin Nernst conductivities in these materials. We acknowledge funding from SPP 1538 SpinCaT programme and HGF-YIG Programme VH-NG-513.

MA 4: Magnetic Heuslers, Half-metals and Oxides I (with TT)

Time: Monday 9:30–12:00 Location: BEY 118

MA 4.1 Mon 9:30 BEY 118

Explaining magnetism in Manganese-based Heusler compounds — •Lukas Wollmann, Gerhard H. Fecher, and Claudia Felser — Max Planck Insitute for Chemical Physics of Solids, Dresden, Germany

From the onset of research in the field of half-metallic ferromagnets, Manganese containing Heusler compounds were the most promising, and most intensely studied trailblazing materials. Accompanying the field of half-metallicity, spintronics emerges as a natural consequence. Focusing on the measurable quantities as Curie temperatures, spin-polarized currents and Hall conductance the field has been, from the beginning on, supported by theoretical methods.

In contrast to purely ferromagnetic Co_2-based Heusler compounds, Manganese containing Heusler alloys (Mn_2YZ and X_2MnZ) exhibit different types of magnetic ordering. The peculiar role of the Manganese atoms and their related magnetic contribution to the quantities of interest shall be elucidated. The main focus lies on the local magnetic structures of the aforementioned material. Following this local perspective, the influence of the magnetic moments on the atomic interplay in form of the Heisenberg exchange interactions is monitored. The computations have been carried out employing the FLAPW DFT code Wien2k and the relativistic Munich SPR-KKR package for the calculation of the exchange constants.

MA 4.2 Mon 9:45 BEY 118

Structural and magnetic properties of the Heusler system Mn-Fe-Ga — •Ajaya Kumar Nayak, Adel Kalache, Michael Nicklas, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

In recent time Mn based Heusler alloys received significant research interest as they show several interesting fundamental as well as functional properties. In particular, Mn_2YZ based materials are considered to be promising candidates for spintronics and spin-torque transfer (STT) applications due to a large spin polarization of the conduction electrons and a large anisotropy in tetragonal phase. The tetragonal ferrimagnetic (FI) compound Mn_3Ga is the center of attraction due to its low saturation magnetization, high Curie temperature (T_C), and high spin polarization. To further tune the magnetic properties of the system we substitute Mn by Fe to obtain Mn_2FeGa up to Fe_2MnGa. All samples crystallize in a pseudo-cubic structure when annealed at 1073 K. Mn_2FeGa undergoes second order paramagnetic (PM) to antiferromagnetic (AFM) ordering around 350 K. In contrast, Fe_2MnGa shows The sample shows a PM to ferromagnetic (FM) ordering around 800 K followed by a first-order FM-AFM transition around 300 K. Here, we present a complete study of the magnetic properties of the Mn-Fe-Ga system with help of various magnetization measurements.

MA 4.3 Mon 10:00 BEY 118

Neutron diffraction study of $Ni_{45}Co_5Mn_{38}Sb_{12}$ Heusler system — •Roshnee Sahoo[1], Amitabh Das[2], KG Suresh[1], Daniel Ebke[3], and Claudia Felser[3] — [1]Department of Physics, Indian Institute of Technology Bombay, Mumbai-400076, India — [2]Solid State

Physics Division, Bhabha Atomic Research Centre, Mumbai- 400085, India — [3]Max Planck Institute of Chemical Physics of Solids, Dresden-01187, Germany

Considerably large martensitic transition temperature has been observed after substituting Co for Ni site in $Ni_{45}Co_5Mn_{38}Sb_{12}$ system. This system exhibits austenite $L2_1$ cubic structure with a=5.96 $\AA$ at high temperatures, while it has orthorhombic structure in the martensitic phase. We have carried out a detailed neutron diffraction study in order to establish the magnetic structure and the nature of magnetic coupling in this system. In $Ni_{45}Co_5Mn_{38}Sb_{12}$ system, from temperature variation of neutron diffraction data has shown that with increase in temperature the moments of 2a and 2f site decrease up to 250 K and after that both decrease. At 300 K, the material is in the austenite phase, which gives a moment of $1.1\mu_B$ at 4a site and $0.8\mu_B$ at 4b site. The fact that the spontaneous magnetization of $2\mu_B$ is obtained from magnetization measurement suggests that the Mn moment at 4a and 4b sites are coupled ferromagnetically in austenite phase. It is also noticed that with increase in temperature the cell volume increases. However, near the martensitic transition there is a decrease of 0.3% of cell volume. Detailed structural and magnetic results, as obtained from the neutron data, will be discussed in the full paper.

MA 4.4 Mon 10:15 BEY 118

Large non-collinearity and spin reorientation in the Mn2YSn Heusler family — •O. Meshcheriakova[1,2], S. Chadov[1], A. Nayak[1], J. Kübler[3], J. Kiss[1], G. André[4], A. Tsirlin[1], W. Schnelle[1], M. Nicklas[1], and C. Felser[1,2] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden Germany — [2]Graduate School of Excellence "Materials Science in Mainz", 55128 Mainz, Germany — [3]Institut für Festkörperphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [4]Laboratoire Léon Brillouin, CEA-CNRS Saclay, Gif-sur-Yvette Cedex, France

Non-collinear magnets provide essential ingredients for next generation memory technology. Recent discoveries have demonstrated the possibility to move certain non-collinear spin structures (skyrmions) at significantly low current densities. To establish such magnetic arrangement, the corresponding materials should possess a non-centrosymmetric crystal structure together with high spin-orbit coupling. Heusler compounds show diverse fundamental properties but in the context of non-collinearity they were not considered so far. Here we present a novel non-collinear tetragonal Mn2RhSn Heusler material exhibiting unusually strong canting of its magnetic sublattices. It undergoes a spin-reorientation transition, induced by a temperature change and suppressed by the external magnetic field. In addition, because of the non-centrosymmetric structure, Dzyaloshinskii-Moriya exchange and magnetic anisotropy, Mn2RhSn is supposed to be a promising candidate for realizing the skyrmion state in the Heusler family.

MA 4.5 Mon 10:30 BEY 118

Design of compensated ferrimagnets based on Mn-rich Heusler compounds — •Stanislav Chadov, Olga Meshcheriakova, Ajaya Nayak, and Claudia Felser — Max-Planck-Institut für Chemische Physik fester Stoffe Nöthnitzer Straße 40 01187 Dresden

Recent developments in the field of MRAM technologies such as ultrafast optical spin-switching has stimulated the search for materials which provide efficient mechanisms of exchange relaxation. The best candidate materials can be provided within the class of the compensated ferrimagnets. Here we propose the design scheme of compensated ferrimagnets based on tetragonal Mn-rich Heusler alloys. Together with the properties typical for antiferromagnets (e.g. exchange bias) we analyze the phenomena (e.g. anomalous Hall effect or MOKE) which are absent in the systems with zero net magnetization.

MA 4.6 Mon 10:45 BEY 118

Atom Probe Tomography of Thin Film Magnetic Heusler Alloy Interfaces — •Torben Boll[1], Niclas Teichert[2], Andreas Hütten[2], and Talaat Al-Kassab[1] — [1]King Abdullah University of Science and Technology (KAUST), Division of Physical Sciences and Engineering, Thuwal 23955-6900, Saudi Arabia — [2]Bielefeld University, Thin Film and Physics of Nanostructures, Universitätsstr. 25, 33615 Bielefeld, Germany

NiMn-X ferromagnetic shape memory alloys have been gaining interest for various applications. For microelectronic devices these alloys have to be made available as thin films. The properties of these films are dominated by the microstructure and especially the interfaces between different layers.

For this study thin film samples of NiMnGa-NiMnSn grown on MgO or Si substrates were prepared by magnetron sputtering. The system was covered with an additional layer of Ag or Ni for protection. Then needle shaped specimens, as required for atom probe tomography, were cut out by means of focused ion beam preparation. The NiMnGa-NiMnSn interface and the MgO-metal interface were characterized with a Local Electrode Atom Probe (LEAP) 4000 HR and a Laser Assisted Wide Angle Tomographic Atom Probe (LAWATAP).

MA 4.7 Mon 11:00 BEY 118

Growth and physical properties of off-stoichiometric Co2Cr0.4Fe0.4Al1.2 Heusler compound — •Ahmad Omar, Marcel Haft, Jan Trinckauf, Christian G.F. Blum, Wolfgang Löser, Silke Hampel, Jochen Geck, Bernd Büchner, and Sabine Wurmehl — Leibniz Institute for Solid State and Materials Research IFW Dresden, Germany

Many Heusler compounds are predicted to be half-metallic ferromagnets and find extensive interest as materials for spintronic applications. Co2Cr0.6Fe0.4Al has been predicted to be 100% spin polarized, but so far, bulk samples as well as thin films do not verify those predictions and various results are fraught with anomalies. Recently, it has been shown that the underlying thermodynamic instability leads to phase transformation via spinodal decomposition in the material. The evolving secondary phase strongly affects the physical properties including spin polarization. One possible way to avoid the spinodal decomposition is to move in the phase diagram and thus avoid the immiscibility gap. We have grown off-stoichiometric Co2Cr0.4Fe0.4Al1.2 composition using optical Floating Zone (FZ) technique, which is known to be the technique of choice for incongruent melting systems such as materials in the Co-Cr- Fe-Al system. We do not observe any spinodal decomposition in our sample. The physical property measurements also match nicely with the theory, which has so far not been possible for Co2Cr1-xFexAl series. We have also performed X-ray Magnetic Circular Dichroism (XMCD) measurements on the sample which are promising compared to the band structure calculations.

MA 4.8 Mon 11:15 BEY 118

Growth of perovskite manganites via MAD Atomic Layer Epitaxy (ALE) — •Markus Jungbauer, Sebastian Hühn, Felix Massel, and Vasily Moshnyaga — I. Physikalisches Institut, Georg-August-Universität, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Interfacial effects between transition metal perovskites lead to many unexpected phenomena due to charge, spin and orbital rearrangements. Recently it was pointed out that reconstructions at the scale of half a perovskite layer can take place to reduce Coulomb energy due to the polarization catastrophe [1]. So deposition techniques which are able to build up perovskites ABO_3 by alternating deposition of AO and BO_2 layers are highly desirable. Utilizing this scheme we grow $La_{1-x}MnO_3$ and $La_{2/3}Sr_{1/3}MnO_3$ on $SrTiO_3$ (100) substrates by metalorganic aerosol deposition (MAD) [2]. We monitor the growth by in situ ellipsometry which enables us to distinguish between a layer by layer and block by block growth mode. Modifications of the stoichiometry of the first two layers SrO and MnO_2 result in profound changes of the structural, electrical and magnetic properties of the films. We explain this by an interplay of interfacial intermixing and electrostatic driving forces which can be reduced by excess MnO_2 in the first layer. Financial support of EU via FP7 (IFOX) is acknowledged.

[1] S. Turner et al, Phys. Rev. B 87, 035418 (2013)
[2] Moshnyaga et.al. Appl. Phys. Lett. 74, 2842 (1999)

MA 4.9 Mon 11:30 BEY 118

Observation of magnetization processes in manganite thin films using the planar Hall effect — •Camillo Ballani, Eduard Unger, Markus Jungbauer, Markus Michelmann, Sebastian Hühn, Danny Schwarzbach, and Vasily Moshnyaga — I.Physikalisches Institut, Universität Göttingen

We present a technique for monitoring magnetization processes in thin magnetic films by a simple voltage measurement. The planar Hall effect (PHE) in ferromagnetic materials, which is a direct consequence of the anisotropic magnetoresistance (AMR), is highly sensitive to changes in the magnetization induced by an in-plane external magnetic field. Therefore, rotation of magnetization as well as flops of single magnetic domains can be investigated by measuring the transverse voltage in a Hall bar structure. This method was applied to manganite thin films ($La_{0.7}Sr_{0.3}MnO_3$ and $La_{0.6}Ba_{0.4}MnO_3$) with thicknesses from 5 nm to 30 nm that were grown by metalorganic aerosol deposition (MAD) technique on $SrTiO_3$ substrates with orientations (100), (110) and (111) and hence with different magnetocrystalline anisotropy. Structures with a Hall bar geometry of various sizes (bar width: 10–300 μm) were processed by electron beam lithography. The films showed AMR ratios up to 1% at temperatures slightly below T_C. The results for the transverse voltage measurements for magnetic hysteresis loops driven by an applied external field are consistent with simultaneously conducted measurements of magneto-optical Kerr effect (MOKE) and fit well to a Stoner-Wohlfarth model. Financial support from EU FP 7 Project IFOX (interfacing oxides) is acknowledged.

MA 4.10 Mon 11:45 BEY 118

Magnetic and electronic properties of $La_{2/3}Sr_{1/3}MnO_3$ with planar order along (100) and (111) — •Sebastian Hühn[1], Markus Jungbauer[1], Ricardo Egoavil[2], Jo Verbeeck[2], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Electron Microscopy for Materials Science (EMAT), Groenenborgerlaan 171, 2020 Antwerp, Belgium

Cation ordering has a large impact on the physical properties of strongly correlated materials. In $AA'BB'O_3$ perovskites A- and B-site ordering can lead to stabilization of the bulk properties, i.e. higher transition temperatures and saturation magnetization. Furthermore interface related properties different from those of bulk materials can emerge. We present an approach of A-site ordering in ferromagnetic-half-metallic $La_{2/3}Sr_{1/3}MnO_3$ by the growth of $(La_{1/2}Sr_{1/2}MnO_3)2n/(LaMnO_3)n$ and $(LaMnO_3)2n/(SrMnO_3)n$ (with n=1...4) superlattices on $SrTiO_3$ (100) and $SrTiO_3$ (111) substrates by metalorganic-aerosol deposition (MAD) with in situ ellipsometric growth control. Structural properties were investigated by STM/AFM, XRD, XRR and TEM-EELS. The resistivity and magnetization were measured between 5-400K by PPMS and MPMS, respectively. Our observation of the Curie point T_C as a function of the parameter n shows a huge difference for the planar order directions (100) and (111). Financial support from EU FP 7, IFOX (interfacing oxides) project is acknowledged.

MA 5: Topological insulators: mostly structure and electronic structure (with HL/O/TT)

Time: Monday 9:30–12:30 Location: POT 051

MA 5.1 Mon 9:30 POT 051

InAs/GaSb compound quantum wells for electrically tunable topological insulator devices — •Georg Knebl[1], Matthias Dallner[1], Robert Weih[1], Sven Höfling[1,2], and Martin Kamp[1] — [1]Universität Würzburg, Deutschland — [2]University of St Andrews, Scotland

InAs/GaSb compound quantum wells (CQW) sandwiched between two AlSb layers and a front/back gate were proposed by Liu et al. [1] to show a topological insulator phase. The advantage of this structure is the possibility to tune the phase transition from a normal to a topological insulator via the front and back gate voltage. In addition, this material combination allows the use of established III/V semiconductor technology for epitaxy and device processing.

We present results on the growth of InAs/GaSb CQWs via molecular beam epitaxy on GaSb and GaAs substrates using different buffers. Furthermore, we will discuss device fabrication on InAs/GaSb layer structures, which requires special care since oxidation or process induced damage can lead to the formation of conducting surface channels. Electrical characterization of Hall bars and the tunability of the transport properties via gates will be reported.

[1] C. Liu, et al., Phys. Rev. Lett. 100, pp. 1-4, (2008)

MA 5.2 Mon 9:45 POT 051

Resolving the linear dispersion relation of topological insulator nanowires — •Johannes Gooth, Bacel Hamdou, August Dorn, Robert Zierold, and Kornelius Nielsch — Institute of Applied Physics, Universität Hamburg, Hamburg, Germany

Due to the linear dispersion relation, charge carriers in the surface states of a topological insulator (TI) behave like relativistic particles described by the Dirac equation for spin-1/2 particles leading to exotic new physics and applications. In bulk topological insulators the linear dispersion relation at the surface has been resolved by angle-resolved photoemission spectroscopy (ARPES). On nanostructures ARPES measurements have not been successful, due to the limited sample size. Instead magnetoelectrical transport measurements became the most common way to indicate the existance of surface states in nanomaterials. However, the linear dispersion relation has not been directly resolved in nanostructures to date.

Here, we show that the linear dispersion relation on the surface of a Bi_2Te_3 nanowire can directly be deduced from gate dependend magnetototransport measurements. Further carrier concentration, mobility and effective mass of the dirac fermions are determined as a function of gate voltage. It can be shown that at 2K the transport in the surface states is dominated by electron-electron interaction.

MA 5.3 Mon 10:00 POT 051

Temperature-dependent surface band gap of Dirac fermions observed at the (111) surface of the crystalline topological insulator Pb-Sn-Se — •Partha S. Mandal[1], Gunther Springholz[2], Günther Bauer[2], Valentine V. Volobuev[2], Andrei Varykhalov[1], Oliver Rader[1], and Jaime Sánchez-Barriga[1] — [1]Helmholtz-Zentrum Berlin — [2]Johannes-Kepler-Universität Linz

Using angle-resolved photoemission, we studied (111)-oriented epitaxial films of Pb-Sn-Se grown by molecular beam epitaxy. The topological-to-trivial-insulator phase transition [1] is monitored probing the bulk valence band as a function of Sn concentration and temperature between 30 K and room temperature. In the topological phase, the topological surface state opens a band gap indicating a mass aquisition that is not caused by broken time reversal symmetry. We discuss this phenomenon in comparison to conventional topological insulators [2] protected by time-reversal symmetry.

[1] P. Dziawa, B. J. Kowalski, K. Dybko, R. Buczko, A. Szczerbakow, M. Szot, E. Łusakowska, T. Balasubramanian, B. M. Wojek, M. H. Berntsen, O. Tjernberg, T. Story, Nature Mat. 11, 1023 (2012).

[2] T. Sato, K. Segawa, K. Kosaka, S. Souma, K. Nakayama, K. Eto, T. Minami, Y. Ando, and T. Takahashi, Nature Phys. 7, 840 (2011).

MA 5.4 Mon 10:15 POT 051

Surface-Dominated Transport on a Bulk Topological Insulator — •Lisa Kühnemund[1], Lucas Barreto[2], Frederik Edler[1], Christoph Tegenkamp[1], Jianli Mi[3], Martin Bremholm[3], Bo Brummerstedt Iversen[3], Christian Frydendahl[2], Marco Bianchi[2], and Philip Hofmann[2] — [1]Leibniz Universität Hannover, Inst. f. Festkörperphysik — [2]Aarhus University, Dep. of Physics and Astronomy, iNANO — [3]Aarhus University, Center for Materials Crystallography, iNANO

Topological insulators are guaranteed to support metallic surface states on an insulating bulk, and one should thus expect that the electronic transport in these materials is dominated by the surfaces states. Alas, due to the high remaining bulk conductivity, surface contributions to transport have so-far only been singled out indirectly via quantum oscillations, or for devices based on gated and doped topological insulator thin films, a situation in which the surface carrier mobility could be limited by defect and interface scattering. Here we present a direct measurement of surface-dominated conduction on an atomically clean surface of Bi_2Te_2Se. Using nano-scale four point setups with variable contact distance, we show that the transport at 30 K is two-dimensional rather than three-dimensional and by combining these measurements with angle-resolved photoemission results from the same crystals, we find a surface state mobility of 390(30) $cm^2V^{-1}s^{-1}$ at 30 K at a carrier concentration of $8.71(7)\times10^{12}$ cm^{-2}.

MA 5.5 Mon 10:30 POT 051

Room temperature high frequency transport of Dirac fermions in MBE grown Sb_2Te_3 based topological insulators — •T. Herrmann[1], P. Olbrich[1], S.N. Danilov[1], Ch. Weyrich[3], J. Kampmeier[3], G. Mussler[3], D. Grützmacher[3], L. Plucinski[3], C.M. Schneider[3], M. Eschbach[3], L.E. Golub[2], V.V. Bel'kov[2], and S.D. Ganichev[1] — [1]University of Regensburg, Regensburg, Germany — [2]Ioffe Institute, St. Petersburg, Russia — [3]Peter Grünberg Institute (PGI) & Jülich Aachen Research Alliance (JARA-FIT), Research Center Jülich, Jülich, Germany

We report on the observation of terahertz (THz) laser radiation induced currents in epitaxially grown Sb_2Te_3 based topological insulators (TI) [1]. We demonstrate that the excitation of the sample with linearly polarized THz radiation results in a photoresponse solely stemming from the surface states of the 3D TI. Our analysis shows that the photocurrent is caused by the photogalvanic effect [2], which emerges in the surface states but is forbidden in the centrosymmetric bulk material. As an important result our measurements demonstrate that the high frequency transport can be obtained in the Dirac fermion system even at room temperature.

[1] Plucinski et al.; J. Appl. Phys. **113**, 053706 (2013)
[2] Weber et al.; Phys. Rev. B **77**, 245304 (2008)

MA 5.6 Mon 10:45 POT 051

Topological Insulator Nanowires by Chemical Vapour Deposition — •Piet Schönherr and Thorsten Hesjedal — Department of Physics, Clarendon Laboratory, University of Oxford, Oxford OX1 3PU, United Kingdom

Topological insulators (TIs) are a new state of quantum matter which insulates in the bulk and conducts on the surface. The study of bulk TIs has been hindered by high conductivity in the bulk, arising from crystalline defects. Such problems can be tackled through compositional engineering or the synthesis of TI nanomaterials. We combined both approaches in a systematic study of various growth parameters to achieve uniform, high purity nanowires with high substrate coverage.

The highlight of this study is the development of a new growth route for nanowires, based on a TiO_2 catalyst rather than the conventional Au. Comparative studies demonstrate that Au significantly contaminates the nanowires, whereas TiO_2 stays well separated. Details of the Au and TiO_2-catalysed growth mechanism were investigated. For Au it was found that the growth mechanism is vapour-liquid-solid. For TiO_2 nanoparticles, in contrast, the growth mechanism can be described in the vapour-solid scheme.

Nanowires of the doped compound $(Bi_{0.78}Sb_{0.22})_2Se_3$ were studied using synchrotron radiation. It was discovered that the material mainly adopts an orthorhombic phase known from Sb_2Se_3. The Raman spectrum is reported and matched with the structural information for the first time. Furthermore, a method to control the length and diameter of Bi_2Se_3 nanowires through laser-cutting was developed.

Coffee break (15 min.)

MA 5.7 Mon 11:15 POT 051

Optoelectronic flow trajectories in topological insulators — •Paul Seifert[1], Christoph Kastl[1], Tong Guan[2], Kehui Wu[2], X. Y. He[2], Yongqing Li[2], and Alexander W. Holleitner[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München — [2]Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

We report on the optoelectronic properties of thin films of the topological insulator $(Bi_xSb_{1-x})_2Te_3$ grown by molecular beam epitaxy. In spatially resolved experiments, we observe photocurrent patterns with positive and negative amplitude [1]. We interpret the patterns to originate from a local photocurrent generation due to potential fluctuations [1]. Exploiting the local photocurrent generation in combination with a sub 100-nm lithography, we visualize the current flow in nanoscale circuits based on topological insulators [2].

[1] C. Kastl, T. Guan, X. Y. He, K. H. Wu, Y. Q. Li, and A. W. Holleitner, Appl. Phys. Lett. 101, 251110 (2012). [2] C. Kastl et al., (2014).

We gratefully acknowledge financial support from the DFG-project HO3324/8 within the SPP 1666 on topological insulators.

MA 5.8 Mon 11:30 POT 051

Polarization-controlled picosecond spin currents in topological insulators — •Christoph Kastl[1], Christoph Karnetzky[1], Helmut Karl[2], and Alexander W. Holleitner[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München, 85748 Garching, Germany — [2]Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

Controlling spin currents in topological insulators may lead to applications in future spintronic devices [1]. Here, we show that surface currents in Bi2Se3 can be controlled by circularly polarized light on a time-scale of a picosecond with a fidelity near unity even at room temperature. We reveal the temporal interplay of such ultrafast spin currents with photo-induced thermoelectric and drift currents in optoelectronic circuits [2].

[1] C. Kastl, T. Guan, X. Y. He, K. H. Wu, Y. Q. Li, and A. W. Holleitner, Appl. Phys. Lett. 101, 251110 (2012).
[2] C. Kastl et al., (2014).

We gratefully acknowledge financial support from the DFG-project HO3324/8 within the SPP 1666 on topological insulators.

MA 5.9 Mon 11:45 POT 051

Scanning Tunneling Microscopy of Ultrathin Topological Insulator Sb_2Te_3 Films on Si(111) grown by Molecular Beam Epitaxy — •Martin Lanius, Jörn Kampmeier, Gregor Mussler, and Detlev Grützmacher — Peter Grünberg Institut, Forschungszentrum Jülich, Germany

Topological insulators (TIs) are a class of materials in the field of condensed matter physics. In addition to the fascinating electronic properties, the Van der Waals growth mode of TIs, i.e. the TI epilayer is only weakly bonded to the substrate, which allows the use of substrates with high lattice mismatch, is of high interest. In this case we have studied the nucleation and growth process of the TI Sb_2Te_3 on Si(111) substrates by STM (Scanning Tunneling Microscopy) and AFM (Atomic Force Microscopy). The thin films from several nanometers thickness down to one quintuple layer thickness have been grown by molecular beam epitaxy. To determine the thickness and composition of the films we used x-ray reflectivity and x-ray diffraction. Further investigations of $Ge_2Sb_2Te_3$, which is a phase-changing material and a topological insulator, and the comparison to the growth mode of Sb_2Te_3 will be presented.

MA 5.10 Mon 12:00 POT 051

Transport of Dirac fermions in the presence of spin-orbit impurities — •Pierre Adroguer[1], Dimitri Culcer[2], and Ewelina Hankiewicz[1] — [1]Institute for Theoretical Physics and Astronomy, Würzburg University, Würzburg, Germany — [2]School of Physics, University of New South Wales, Sidney, Australia

The recent exprimental realizations of three dimensional topological insulators (3DTI) have provided a new tool to investigate Dirac physics.

Indeed, these materials exhibit an insulating bulk and a single metallic surface state described by Dirac fermion physics.

In the regime of weak scalar disorder, Dirac fermions do not backscatter because of time-reversal symmetry. Further, this absence of backscattering leads to a weak antilocalization correction (an increase in conductivity in the absence of magnetic field, due to quantum interference of conjugated paths) [1,2].

In this presentation, we will review these phenomena, and show how these features are modified when there are spin-orbit impurities in the Dirac fermion systems.

We acknowledge financial support via grant HA 5893/4-1 within SPP 1666.

[1] G. Tkachov and E. M. Hankiewicz, Phys. Rev. B 84, 035444 (2011)
[2] P. Adroguer, D. Carpentier, J. Cayssol, and E. Orignac, New Journal of Physics 14, 103027 (2012)

MA 5.11 Mon 12:15 POT 051

Oscillatory surface dichroism of the insulating topological insulator Bi_2Te_2Se — •Susmita Basak[1], Madhab Neupane[2], Hsin Lin[1], N. Alidoust[2], S.-Y. Xu[2], Chang Liu[2], I. Belopolski[2], G. Bian[2], J. Xiong[2], H. Ji[3], S. Jia[3], S.-K. Mo[4], M. Bissen[5], M. Severson[5], N. P. Ong[2], T. Durakiewicz[6], R. J. Cava[3], A. Bansil[1], and M. Z. Hasan[2] — [1]Department of Physics, Northeastern University, Boston, Massachusetts, USA — [2]Joseph Henry Laboratory and Department of Physics, Princeton University, Princeton, New Jersey, USA — [3]Department of Chemistry, Princeton University, Princeton, New Jersey, USA — [4]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California, USA — [5]Synchrotron Radiation Center, Stoughton, Wisconsin, USA — [6]Condensed Matter and Magnet Science Group, Los Alamos National Laboratory, Los Alamos, New Mexico, USA

We present a study of the effect of angular momentum transfer between polarized photons and topological surface states of the insulating topological insulator Bi_2Te_2Se using circular dichroism-angle resolved photoemission spectroscopy. The photoelectron dichroism demonstrate a dramatic sign flip with the change of photon frequency and we show that this is a consequence of a strong coupling between the photon field and the spin-orbit nature of the initial Dirac states on the surface. Our studies reveal the intrinsic dichroic behavior of topological surface states and point toward the potential utility of bulk insulating topological insulators in opto-spintronics device applications.

MA 6: Focussed Session: Frontiers of Electronic Structure Theory - Non-equilibrium Phenomena at the Nano-scale (with O)

Non-equilibrium processes such as charge and heat transport are central to electronic and thermoelectric applications. Understanding these phenomena at the nanoscale challenges both theory and experiment. Basic theoretical issues are related to the role of quantum mechanics, the interplay of ballistic, diffusion and hopping processes, the importance of dissipation, the effect of electronic correlation, and the signatures of unusual quantum states. On the experimental side devising measurements to unravel these phenomena in a controlled way poses severe difficulties. In this regard, optical lattices of cold atoms are emerging as a powerful laboratory to test theoretical models and discover unforeseen phenomena.

This symposium will cover current issues in the field by bringing together scientists working in different specific areas with the aim of fostering interdisciplinary discussion, assessing current theoretical understanding, and indicating future goals with emphasis on electronic structure theory.

Organizers: Roberto Car (Princeton), Kristian S. Thygesen (Lyngby) and Matthias Scheffler (Berlin)

Time: Monday 10:30–13:15 Location: TRE Ma

Topical Talk MA 6.1 Mon 10:30 TRE Ma

Molecular junction transport: some theoretical and computational considerations — •Mark Ratner[1] and Matthew Reuter[2] — [1]Chemistry, Northwestern University, Evanston Illinois 60208 USA — [2]Chemistry, Northwestern University, Evanston Illinois 60208 USA

Following the development of break junction techniques, and very elegant measurements by many labs worldwide, the understanding of the community for single molecule transport junctions on the experimental side has been very nicely unified. While there are still challenges, interpretations of the transport (and indeed of some second-order response properties) is now quite sophisticated.

There have been major advances in the computational approaches also, and in many cases, computations and measurements can be compared quantitatively. But there are some remaining difficulties in the computational and theoretical approaches, and this talk will discuss a few of them.

The topics addressed will be: single molecule aspects, histograms and their usage, time-dependence of the transport, and ghost transmission and computational accuracy.

MA 6.2 Mon 11:00 TRE Ma

On the description of biased nanocontacts from ab initio — •Steven Achilles[1], Jürgen Henk[1], Michael Czerner[2], Christian Heiliger[2], and Ingrid Mertig[1] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, D-06099 Halle, Germany — [2]I. Physikalisches Institut, Justus Liebig University, D-35392 Giessen, Germany

A suitable description of arbitrary shaped and biased nanocontacts is very important for investigating and predicting physical effects of materials on the nanometer scale. In particular, the electronic transport properties under finite bias voltages are of great interest.

To account for systems under finite bias we extended our Korringa-Kohn-Rostoker Green's function method [1] to the Keldysh formalism [2]. The method was developed for different types of geometries, i.e. planar junctions [3] and embedded real-space clusters [4]. Both implementations include a self-consistent treatment of the electronic structure under external bias using the nonequilibrium density.

We present ab initio results of voltage drops, the charge relaxation under finite bias voltage and current-voltage characteristics for different types of geometries.

[1] R. Zeller, P.H. Dederichs, B. Ujfalussy, L. Szunyogh, and P. Weinberger, Phys. Rev. B 52, 8807 (1995).; P. Zahn, I. Mertig, R. Zeller, and P.H. Dederichs, Mat. Res. Soc. Symp. Proc. 475, 525 (1997).
[2] L.V. Keldysh, Sov. Phys. JETP 20 (4), 1018-1026 (1965).
[3] S. Achilles et al., Phys. Rev. B 88 (12), 125411 (2013).
[4] S. Achilles et al., to be published

MA 6.3 Mon 11:15 TRE Ma

Elasticity changes in molecular junctions under bias: an ab-initio study — •Clotilde S. Cucinotta[1], Meilin Bai[1,2], Ivan Rungger[1], Shmin Hou[2], and Stefano Sanvito[1] — [1]School of Physics and CRANN, Trinity College Dublin, College Green, Dublin 2, Ireland — [2]2Key Laboratory for the Physics and Chemistry of Nanodevices, Department of Electronics, Peking University, Beijing 100871, China

Non-conservative current induced forces are at the origin of a rich variety of dynamical processes, including vibrations, rotations, phonon energy flow, desorption and reactions. The ability to simulate these phenomena paves the way for crucial advances in interface physics and in molecular electronics. New insights into how the presence of non-conservative forces can affect the vibrational spectrum of prototypic Au-H2-Au nano-junctions are obtained by the Non Equilibrium Green Functions approach combined with Density Functional Theory as implemented in the Smeagol code [1]. The modification of the phonon spectrum of the junction in the presence of an external bias is for the first time analysed, in terms of charge redistribution caused by the electron flow, potential drop and differences in an average distance collective variable. Phonon modes changes are related to a change in bias of some of the elastic constants.The importance of electric field vs. current effects is compared. The elasticity changes of the molecular junction with bias are interpreted in terms of the current flowing through the system. [1] http://www.smeagol.tcd.ie/SmeagolDownloads.htm.

MA 6.4 Mon 11:30 TRE Ma

Carbon nanotubes decorated with magnetic clusters: magnetism, electron transport and gas sensing — •Zeila Zanolli[1] and Jean-Christophe Charlier[2] — [1]Forschungszentrum Juelich, PGI and IAS, Juelich, Germany — [2]IMCN, Université catholique de Louvain (UCL), Belgium

In this work, first-principles techniques and non-equilibrium Green's function approaches are used to investigate magnetism and spin-polarized quantum transport in carbon nanotubes (CNTs) decorated with transition metal magnetic nanoclusters (NC).

For small cluster sizes (< 1 nm), *ab initio* calculations predict a considerable local magnetic moment that induces spin polarization in the host CNT due to a strong mutual interaction with the magnetic NC. Such a huge local magnetic perturbation can be tailored by molecular adsorption on the metallic NC, thus modifying both the magnetization and the spin-dependent conductance of the hybrid CNT-NC system. The adsorption of benzene on Ni- or Pt-decorated metallic CNTs has been investigated as a test case. The ab initio simulations demonstrate that the magnetization change due to the absorption of a single C_6H_6 molecule should be large enough to be detected experimentally using either magnetic-AFM or SQUID magnetometer. Consequently, the present research suggests a novel approach for single molecule gas detection, based on local magnetic moment measurements in CNT-NC hybrid systems [1].

[1] Z. Zanolli, J.-C. Charlier, ACSnano **6** (2012) 10786-10791.

15 min. break

Topical Talk MA 6.5 Mon 12:00 TRE Ma

Insight into Charge Transport in Molecular Junctions from Ab Initio Theories of Level Alignment — •Jeffrey B. Neaton — Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, CA, USA — Department of Physics, University of California, Berkeley, Berkeley, CA — Kavli Energy Nanosciences Institute, Berkeley, CA

Recent scanning tunneling microscope-based break-junction experiments of molecular junctions – devices formed by trapping organic molecules between macroscopic metallic electrodes – have reported robust conductance, thermopower, switching behavior, quantum interference effects, spin-filtering phenomena, and even nonlinear effects such as rectification, establishing such junctions as unique and revealing windows into the physics of charge transport at the molecular scale. In this talk, I will summarize a predictive approach to compute and understand the transport properties of molecular junctions with good accuracy. Our approach includes important exchange and correlation effects missing in standard DFT Kohn-Sham junction level alignment, building on self-energy corrections within a GW approximation. Advantages and limitations of our approach will be discussed quantitatively in the context of a direct comparison with recent photoemission and transport measurements. I will also describe applications of this approach to select junctions exhibiting novel trends in conductance, thermopower, and nonlinear IV characteristics, where new physical insight is obtained by relating computed transport phenomena to junction structure and chemistry.

MA 6.6 Mon 12:30 TRE Ma

Towards First-Principles Modeling of Solvent Effects in Photo-Catalytic Water Splitting — •Stefan Ringe, Harald Oberhofer, Sebastian Matera, and Karsten Reuter — Technische Universität München, Germany

In the context of solar energy conversion the search for new materials for photo-catalytic water splitting has received new impetus. While in general powerful, computational screening approaches are struggling with the complexity of the underlying physical processes at the solid-liquid interface. Recent work points in particular at the necessity to include at least an efficient description of solvent screening effects to compute meaningful descriptors even in simple computational hydrogen electrode approaches. To this end, we present an implementation of the modified Poisson-Boltzmann (MPB) implicit solvation model in the highly parallel and numerically efficient all-electron DFT code FHI-aims. Optimally integrating into this code environment, we solve the MPB equation in a novel approach based on an expansion of the electrostatic potential in the localized basis functions of FHI-aims. In contrast to common numerical multi-grid solvers this approach can directly make use of the optimized integration schemes used to reach self-consistency and removes the need for numerical interpolation between different grids. We demonstrate the approach and its efficiency for a range of molecular test systems, and show first results for catalytic water splitting on gold nano-clusters.

MA 6.7 Mon 12:45 TRE Ma

Towards a combined QM/MM and implicit solvent description of photoelectrochemical processes — •Markus Sinstein[1], Daniel Berger[1], Ran Jia[2], Volker Blum[3], Harald Oberhofer[1], and Karsten Reuter[1] — [1]Technische Universität München, Germany — [2]Jilin University, P.R. China — [3]Duke University, USA

Photoelectrochemical systems are widely explored to drive energy-relevant redox reactions like water splitting or CO_2 reduction. The detailed analysis of the involved elementary processes via first-principles calculations is challenged by the necessity to simultaneously account for the extended semiconductor photocatalyst and the liquid electrolyte. Especially for charge (proton and/or electron) transfer steps traditionally employed periodic boundary condition approaches involve charged supercells with difficult to control finite size errors. To this end, we present a solid state QM/MM embedding approach, in which only a finite cluster model of the photocatalyst surface is treated quantum mechanically and the correct Madelung potential of the periodic system is obtained by embedding into a charge field. For the efficient modeling of photoelectrochemical processes we combine this approach with an implicit solvation scheme within the DFT package FHI-aims. Finally, we also show early test results of the combined QM/MM implicit solvent model.

MA 6.8 Mon 13:00 TRE Ma

Ab-initio Simulation of Molecular Networks on the Surface of Water — •Ralph Koitz, Marcella Iannuzzi, Ari P Seitsonen, and Jürg Hutter — University of Zurich, Zurich, Switzerland

Molecules adsorbed on surfaces play an important role in catalysis, surface science, and nanotechnology. Traditionally, research has focused on various adsorbates atop metals and metal oxides using computational and surface-science techniques. More recently, however, it was demonstrated that ordered monolayer networks can also be formed on the surface of liquid water by using metal ions to bind together multidentate precursor molecules. As these assemblies are difficult to characterize, computational methods can provide valuable insight into their formation and structure.

In this contribution we present large-scale DFT-based molecular dynamics simulations of the formation of a network of *tris*-terpyridine-derived molecules (TTPB) on a water slab. In particular, we focus on the structure of the molecule on the surface, the mechanism of Zn^{2+} ion insertion from the solution and the subsequent linking of molecules into aggregates. We employ the metadynamics method to quantify the free energy surface of the involved processes. Our results provide detailed insight into on-surface and subsurface diffusion in this system and chemical reactions of TTPB on the surface of water.

MA 7: ThyssenKrupp Electrical Steel Dissertationspreis der AG Magnetismus

Ziel dieses von der ThyssenKrupp Electrical Steel gestifteten Preises (Preisgeld 1000 €) ist die Anerkennung herausragender Forschung im Rahmen einer Doktorarbeit und deren exzellente Vermittlung in Wort und Schrift. Wissenschaftlich herausragende Dissertationen auf dem Fachgebiet Magnetismus in Theorie, Grundlagen und/oder Anwendungen, die im Jahr 2012 oder 2013 an einer deutschen Hochschule abgeschlossen wurden, konnten nominiert werden. Auswahlverfahren: Ein von der AG Magnetismus eingesetztes Preiskomitee ermittelte unter den Einsendungen bis zu vier Finalisten, die in dieser Sitzung einen kurzen 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.

Time: Monday 12:30–14:00 Location: HSZ 04

Presentations by Nominees

MA 8: Focus Session: New trends in Molecular Magnetism (with O/TT)

Organizers: J. Schnack (U. Bielefeld), O. Waldmann (U. Freiburg)

During the past 25 years molecular magnetism has developed into a broad field. Today's major research directions include applications in quantum computing or as quantum simulators as well as the use as sub-Kelvin magnetic refrigerants. For direct manipulation as part of spintronic systems molecules are deposited and manipulated on surfaces. The progress of this interdisciplinary field is intimately related to the ability of coordination chemists to synthesize unprecedented molecules, to the ability of experimental physicists to characterize them as well as to the ability of theorists to model their properties.

Time: Monday 15:00–17:30 Location: HSZ 04

Topical Talk MA 8.1 Mon 15:00 HSZ 04

Spin dynamics in Molecular Nanomagnets — •Stefano Carretta — Dipartimento di Fisica e Scienze della Terra, Universita' di Parma, I-43124 Parma, Italy

Molecular nanomagnets (MNMs) have been test beds for addressing several quantum phenomena. In particular, one of the major current objectives is to exploit their coherent spin dynamics for quantum information processing (QIP). We show that recently developed instrumentation yields the four-dimensional inelastic-neutron scattering function and enables the direct determination of the spin dynamics [1]. We use the Cr8 antiferromagnetic ring as a benchmark to demonstrate the potential of this approach, which allows us, for instance, to examine how quantum fluctuations propagate along the ring. We show that parameters of the spin Hamiltonian can be reliably calculated ab-initio. In particular, we present a flexible and effective ab-initio scheme to build many-body models for MNMs, and to calculate magnetic exchange couplings and zero-field splittings [2]. We have applied this scheme to three paradigmatic systems, the antiferromagnetic rings Cr8 and Cr7Ni and the single molecule magnet Fe4 and have found excellent agreement with experimental results. At last, we discuss the dynamics of ensembles of spin systems coherently coupled to microwave photons in coplanar waveguide resonators. We introduce a scheme to perform QIP that is based on a hybrid spin-photon qubit encoding [3].

[1] M. Baker et al, Nature Physics 8, 906 (2012); [2] A. Chiesa et al, Phys. Rev. Lett. 110, 157204 (2013); [3] S. Carretta, et al, Phys. Rev. Lett. 111, 110501 (2013).

Topical Talk MA 8.2 Mon 15:30 HSZ 04

Exchange interaction in lanthanides — •Liviu Chibotaru, Liviu Ungur, Naoya Iwahara, and Veaceslav Vieru — Theory of Nanomaterials Group, KU Leuven, Heverlee, Belgium

Using ab initio, DFT and model calculations we analyze the main features of exchange interactions in lanthanide complexes.

Andersons superexchange model is applied for analytical derivation of exchange interaction between total magnetic moments $\mathbf{J}_1$ and $\mathbf{J}_2$ corresponding to ground atomic multiplets of two exchange-coupled lanthanide ions. Despite the common belief that the exchange interaction is of $\sim \mathbf{J}_1 \cdot \mathbf{J}_2$ form, we find it strongly anisotropic. If the crystal field (CF) on Ln sites exceeds significantly the exchange splitting, the exchange interaction between low-lying CF doublet states generally becomes of non-collinear Ising type.

In the case of exchange-coupled lanthanide ion ($\mathbf{J}$) and isotropic magnetic center ($\mathbf{S}$) the exchange interaction is found not to be of the form $\sim \mathbf{J} \cdot \mathbf{S}$, as supposed before, but again very anisotropic. When the CF splitting on Ln exceeds the exchange splitting, the exchange interaction between the low-lying CF doublet on Ln and the isotropic spin generally becomes of collinear Ising type.

Finally, we give arguments why the mixed Ln-TM complexes are more efficient SMMs than pure Ln ones despite less anisotropic magnetic ions involved.

Topical Talk MA 8.3 Mon 16:00 HSZ 04

Cool molecules — •Marco Evangelisti — Instituto de Ciencia de Materiales de Aragón, CSIC - Universidad de Zaragoza, Departamento de Física de la Materia Condensada, 50009 Zaragoza, Spain

The recent progress in molecule-based magnetic materials exhibiting a large magnetocaloric effect at liquid-helium temperatures is reviewed. Advanced applications and future perspectives in cryogenic magnetic refrigeration are also discussed.

Topical Talk MA 8.4 Mon 16:30 HSZ 04

Bulk and submonolayer studies of novel single-ion molecular magnets — •Jan Dreiser — Ecole Polytechnique Federale de Lausanne, Institute of Condensed Matter Physics, 1015 Lausanne, Switzerland — Swiss Light Source, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

Single-ion magnets (SIMs) [1,2] contain a single transition-metal or rare-earth ion embedded in an organic ligand. In contrast to many other mononuclear molecular magnets, SIMs exhibit long magnetization relaxation times at low temperatures ranging from milliseconds to more than hours. In order to exploit their properties in possible applications they should be organized and addressable one-by-one [3]. A promising path to achieve this goal is the deposition of submonolayers of SIMs on to surfaces.

In this talk I will report on our recent studies of the Er(trensal) SIM [2] in which the Er(III) ion is seven-fold coordinated to the very robust tripodal ligand. In addition to the investigations of the bulk phase I will present first results obtained on (sub)monolayer deposits on metallic surfaces using X-ray magnetic circular dichroism and scanning tunneling microscopy.

[1] N. Ishikawa, M. Sugita, T. Ishikawa, S.-y. Koshihara, Y. Kaizu, J. Am. Chem. Soc. 2003, 125, 8694; [2] K. S. Pedersen, L. Ungur, M. Sigrist, A. Sundt, M. Schau-Magnussen, V. Vieru, H. Mutka, S. Rols, H. Weihe, O. Waldmann, L. F. Chibotaru, J. Bendix, J. Dreiser, submitted; [3] D. Gatteschi, A. Cornia, M. Mannini, R. Sessoli, Inorg. Chem. 2009, 48, 3408.

Topical Talk MA 8.5 Mon 17:00 HSZ 04

When Organic Materials Interact with Ferromagnetic Surfaces: A First-Principles Perspective — •Nicolae Atodiresei — Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The adsorption of π-conjugated organic materials on ferromagnetic surfaces offers the possibility to merge the concepts of molecular electronics with spintronics to build future nanoscale data storage, sensing and computing multifunctional devices. Based on the density functional theory, we performed theoretical studies to understand how to tailor the magnetic properties of organic-ferromagnetic interfaces. For such hybrid systems, the magnetic properties like molecular magnetic moments and their spatial orientation, the spin-polarization and the magnetic exchange coupling can be specifically tuned by an appropriate choice of the organic material and ferromagnetic surface. [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., Nature 493, 509 (2013); [4] M. Callsen et al., Phys. Rev. Lett. 111, 106805 (2013).

MA 9: Magnetic Nanoparticles

Time: Monday 15:00–18:00 Location: HSZ 401

MA 9.1 Mon 15:00 HSZ 401

Spin structure of MnO and FePt@MnO nanoparticles — •Xiao Sun[1], Alice Klapper[1], Yixi Su[2], Kirill Nemkovski[2], Andrew Wildes[3], Oskar Koehler[4], Heiko Bauer[4], Anna Schilmann[4], Wolfgang Tremel[4], Oleg Petracic[1], and Thomas Brueckel[1] — [1]Jülich Centre for Neutron Science JCNS-2 und Peter Grünberg Institut PGI-4, Forschungszentrum Jülich GmbH — [2]Jülich Centre for Neutron Science JCNS Forschungszentrum Jülich GmbH, Outstation at MLZ — [3]Institut Laue-Langevin, Grenoble, France — [4]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg-Universität Mainz

FePt@MnO heterodimer nanoparticles (NPs) are a novel type of multifunctional material.We have focused on the spin structure inside single MnO NPs and the influence of the exchange bias inside FePt@MnO heterodimer NPs onto the spin structure of MnO NPs. MnO NPs and FePt@MnO NPs with various sizes have been studied using SQUID magnetometry. The exchange bias effect has been observed in FePt@MnO NPs by the shift of hysteresis loops at different temperatures suggesting a magnetic coupling between FePt and MnO NPs. An exchange bias shift is also observed in single MnO NPs which is due to the coupling of the antiferromagnetic MnO core to a ferromagnetic Mn2O3 or Mn3O4 shell. The antiferromagnetic order parameter of MnO has been measured in both single MnO and FePt@MnO NPs using polarized neutron scattering. For comparison with the experimental findings, the spin structure inside single MnO NPs and FePt@MnO dimer NPs are simulated with Monte Carlo methods.

MA 9.2 Mon 15:15 HSZ 401

Magnetic Properties of FePt and FePt@MnO Heterodimer Nanoparticles and their self assemblies — •Alice Klapper[1], Sabrina Disch[2], Xiao Sun[1], Ulrich Rücker[1], Oskar Köhler[3], Heiko Bauer[3], Wolgang Tremel[3], Oleg Petracic[1], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich, GERMANY — [2]Institut Laue-Langevin, F-38042 Grenoble Cedex 9, FRANCE — [3]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg-Universität Mainz, 55099 Mainz, GERMANY

On the length scale of few nanometers, surface effects are not negligible and therefore play an important role for the magnetic behavior of nanoparticles (NP). In this work we investigate the magnetic properties of FePt NP and the change of these properties due to an exchange interaction with an attached antiferromagnetic NP, i.e. FePt@MnO heterodimer NP. The connection of the two NP lead to an increase of the blocking temperature compared to the FePt NP proven by ZFC curves obtained from SQUID measurements. Polarized SANS measurements in a magnetic field have been performed to measure the magnetic form factor of the NP. To investigate the ordering phenomenon and interaction between the NP the samples under study have been deposited on silicon substrates. The self-assembly was studied using AFM and GISAXS instruments. While the FePt NP show a long range ordered structure the heterodimer NP order in a short range structure which is dominated by the larger part of the dimer, i.e. the MnO NP.

MA 9.3 Mon 15:30 HSZ 401

Magnetic Properties of Self-Assembled Fe Nanoislands on Barium Titanate (001) — Remya K. Govind[1], Vasili Hari Babu[2], Cheng-Tien Chiang[1,3], Elena Magnano[4], Federica Bondino[4], Reinhard Denecke[2], and •Karl-Michael Schindler[1] — [1]Martin-Luther-Universität Halle-Wittenberg, Halle — [2]Universität Leipzig, Leipzig — [3]Max-Planck-Institut für Mikrostrukturphysik, Halle — [4]IOM-CNR, Trieste, Italy

The coercivity and saturation magnetization of ultrathin films of Fe on a $BaTiO_3$(001) single crystal substrate have been determined using magneto-optic Kerr effect (MOKE) and X-ray magnetic circular dichroism (XMCD) as a function of annealing temperature. Films deposited at room temperature exhibit bulk-like properties, whereas with increasing annealing temperature coercivity increases and saturation magnetization decreases. Investigations with scanning electron microscopy (SEM) and low-energy electron diffraction (LEED) reveal that annealing causes a morphology transformation from a continuous flat film, which completely covers the substrate, to nanoislands via self-assembled growth. The morphology and size of the islands imply stronger pinning of domain walls or complex magnetic structures as the origin of their particular magnetic properties.

MA 9.4 Mon 15:45 HSZ 401

Temperature and size dependent investigation of the spin structure in bismuth ferrite nanoparticles — •Soma Salamon[1], Joachim Landers[1], Werner Keune[1], Marianela Escobar[2], Doru Lupascu[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Duisburg, Germany — [2]Institute for Materials Science and CENIDE, University of Duisburg-Essen, Essen, Germany

The size and temperature dependence of the cycloidal spin structure in multiferroic bismuth ferrite ($BiFeO_3$) nanoparticles was examined by Mössbauer spectroscopy. Different sized particle samples (d≥50 nm) were synthesized by a wet chemical method and analyzed at different temperatures to gain insight on the temperature dependent anharmonicity of the spin cycloid. A model has been developed to evaluate the line shape of spectra, making it possible to determine the anharmonicity from high resolution experimental spectra. We found that the anharmonicity of the long range cycloidal structure decreases at higher temperatures, starting at 150-200 K and finally reaching the harmonic state at about 400 K. Using three different sized particle samples, we were also able to show a decrease of the Néel temperature from about 652 K for 1 μm particles down to 632 K for 50 nm particles, in addition to an increasingly broader distribution of Néel temperatures for decreasing particle sizes. The spin cycloid has been shown to exist in all particle samples, despite the 50 nm particles having a mean diameter that is below the period length of the cycloid (≈62 nm). This work is supported by MERCUR (Stiftung Mercator and UAMR).

MA 9.5 Mon 16:00 HSZ 401

Magnetic Anisotropy and relaxation of 24 single $43\ nm$ Fe/Fe_xO_y **core/shell-nanocubes** — •Alexandra Terwey[1], Sabrina Masur[1], Ralf Meckenstock[1], Christian Derricks[1], Benjamin Zingsem[1], Florian Römer[1], Miguel Comensana-Hermo[2], and Michael Farle[1] — [1]AG Farle, Experimentalphysik, Universität Duisburg Essen, Germany — [2]Centre de Recherche Paul Pascal, CNRS, Universite de Bordeaux, France

Due to their large surface contribution nano particles and small agglomerates hold unique magnetic properties distinguishing them from bulk or thin film material. Here, ferromagnetic resonance measurements of single $43nm$ edge length Fe/Fe_xO_y core/shell nanocubes are shown with full angle dependence. These measurements performed simultaneously on 22 of these nanocubes and on two dimers prove that the cubes show the same crystalline anisotropy field $\frac{K_4}{M} = 25mT$ which is surprisingly in the same range as that of bulk iron ($28mT$). SQUID measurements show a magnetization of $M = 2 \pm 0.5 \cdot 10^5 \frac{A}{m}$ which is roughly 10% of the value of bulk iron. Considering a ferrimagnetic Fe_xO_y shell, $d = 7nm$, the magnetization should be reduced to about 40%. This behaviour can be explained by an additional contribution such as shell anisotropy or a decrease of the magnetic moment at the internal interface. Furthermore, we find a small FMR linewidth of $4mT$ which corresponds to a damping of $\alpha = 0.045$ matching the linewidth of high quality epitaxial Fe films.

15 min. break

MA 9.6 Mon 16:30 HSZ 401

Magnetic proximity effects in nanoparticle-composite systems — •Genevieve Wilbs[1], Oleg Petracic[1], Emmanuel Kentzinger[1], Joachim Gräfe[2], Eberhard Goering[2], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institute PGI, JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Max-Planck-Institute for Intelligent Systems, 70569 Stuttgart, Germany

In recent years, nanoparticle assemblies have shifted into the focus of scientific interest because they behave neither like bulk material nor correspond to isolated particles. Hence, they offer the possibility to fabricate 'artificial materials' with novel emerging physical properties for a broad range of applications. We report about the magnetic properties of self-assembled iron oxide nanoparticle superlattices. The particles have a diameter of 20 nm and are covered with an organic surfactant shell. By applying them onto a silicon substrate via spin-coating, they form self-organized sub-monolayers. The lateral order is demonstrated by GISAXS (Grazing Incidence Small Angle X-ray Scattering) and SEM (Scanning Electron Microscope) studies. Using SQUID (Superconducting Quantum Interference Device) magnetometry, it is shown that the particles exhibit superspin glass behavior due to dipolar inter-particle interactions. If the organic matrix is exchanged by a polarizable metal like platinum, the superspin glass behavior is partially suppressed and the inter-particle interactions become dominated by the polarization of Pt.

MA 9.7 Mon 16:45 HSZ 401

Transport of superparamagnetic particles on magnetically structured exchange bias bilayer systems for enhanced mixing in microfluidic devices — •Iris Koch, Dennis Holzinger, Daniel Lengemann, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

The active mixing of two aqueous fluids in a microfluidic device obtained via controlled movement of superparamagnetic particle rows above micromagnetic stripe-patterned exchange bias bilayer systems with head-to-head and tail-to-tail orientation of the magnetization in adjacent domains parallel to the short stripe axis,[1] fabricated via ion bombardment induced magnetic patterning (IBMP), was experimentally optimized by investigating the mixing efficiency as a function of the mixing parameters, i.e. the concentration of magnetic particles, the movement scheme of the particles while mixing and both the frequency and pulse shape of the external magnetic field responsible for the particle transport. It is shown that the mixing efficiency is doubled as a result of the optimization procedure as compared to prior investigations. Hence, the active mixing due to the particle movement is five times faster compared to passive mixing via thermal diffusion.

[1] D. Holzinger, D. Lengemann, F. Göllner, D. Engel and A. Ehresmann, Appl. Phys. Lett. 100, 153504 (2012)

MA 9.8 Mon 17:00 HSZ 401

Microfluidic device using anchored one-dimensional, chain-like superstructures of superparamagnetic beads for controllable particle filtering — •Patrick Stohmann, Bernhard Eickenberg, and Andreas Hütten — Department of Physics, Thin Film and Physics of Nanostructures, University of Bielefeld, D-33615 Bielefeld, Germany

Superparamagnetic beads are of interest for microfluidic applications. They can be manipulated via external homogeneous magnetic fields and their functionalized surface allows for the immobilization of various bio-molecules. The presence of an external magnetic field results in an alignment of the particles to chain-like superstructures. When the magnetic field is rotated, the chains follow the movement of the field. Inside a microfluidic channel, the ends of the chains can be anchored on the bottom of the channel. Based on this method, a microfluidic particle filter device was developed that allows for controlling its filter activity by changing the direction of the external field. A regular pattern of anchorbeads was created on the channel bottom by standard lithography. This pattern serves as a substructure for the field-induced agglomeration of magnetic chains. A magnetic field perpendicular to the channel bottom causes the chains to protrude into the liquid flow. Switching the field direction by 90° yields a rapid decrease of the chain-liquid-interaction. The microfluidic particle filter device may enhance the functionality of lab-on-a-chip systems. Chemical interactions of specific dissolved particles with the surface functionalization of the beads may realize on-demand filtering of molecules or cells.

MA 9.9 Mon 17:15 HSZ 401

ON THE NONLINEAR RESPONSE OF NON-INTERACTING ELECTRIC DIPOLES AND SINGLE DOMAIN FERROFLUID PARTICLES SUBJECTED TO STRONG ALTERNATING AND DC BIAS FIELDS — Y.P. Kalmykov[1], •William T. Coffey[2], and N. Wei[3] — [1]University of Perpignan, Perpignan, France — [2]Department of Electronic and Electrical Engineering, Trinity College, Dublin — [3]Department of Electronic and Electrical Engineering, Trinity College, Dublin

The perturbation theory approach to the nonlinear dielectric relaxation of noninteracting permanent electric dipoles (W.T.Coffey and B.V.Paranjape, Dielectric and Kerr Effect Relaxation in Alternating Electric Fields, Proc. R.Ir. Acad. Section A, 78, 17 (1978)) and the analogous magnetic relaxation of ferrofluids is revisited for the particular case of a strong D.C. bias field superimposed on a strong A.C. field. Unlike weak A.C. and strong bias D.C. fields, a frequency dependent D.C. term now appears in the response as well as additional nonlinear terms at the fundamental and second harmonic frequencies. These may be experimentally observable particularly in the ferrofluid application, the corresponding result for the D.C. term for anomalous relaxation is also given.

MA 9.10 Mon 17:30 HSZ 401

Magnetische Eigenschaften von Co80Ni20-Nanostäbchen — •Juliane Perl, Sara Liébana Viñas, Benjamin Zingsem, Anna Elsukova, Marina Spasova und Michael Farle — Experimentalphysik AG Farle, Universität Duisburg-Essen

Magnetische Co80Ni20-Nanostäbchen werden durch Reduktion von Metallacetaten in flüssigem Polyol nass-chemisch synthetisiert. Die Partikel besitzen eine mittlere Länge von 52 nm und Durchmesser von 6,5 nm sowie ein Aspektverhältnis von 8-9. Die HR-TEM Aufnahmen zeigen, dass die Nanostäbchen in hexagonaler Struktur kristallisieren, wobei die <0001>-Richtung parallel zur Wachstumsrichtung der Stäbchen liegt. Die Partikel sind natürlich oxidiert mit einer Oxidschichtdicke von 1,5-2 nm. Die magnetischen Eigenschaften werden mit dem SQUID-Magnetometer im Zero-Field-Cooled- und Field-Cooled-Modus gemessen. Die Magnetisierungskurven (ZFC) der in einer Matrix ausgerichteten Nanostäbchen zeigen im Vergleich zu einer Pulverprobe (0,1 T) bei Raumtemperatur eine hohe Koerzitivfeldstärke (0,24 T), die durch die Form- und magnetokristalline Anisotropie verursacht wird. Die FC-Messungen zeigen bei tiefen Temperaturen eine vertikale und horizontale Verschiebung (Exchange-Bias) sowie eine Verbreiterung der Magnetisierungskurven die durch die Exchange-Anisotropie hervorgerufen werden. Die magnetischen Eigenschaften der hoch anisotropen Co80Ni20-Nanopartikel lassen sich variieren und sind geeignet für permanentmagnetische Anwendungen.

MA 9.11 Mon 17:45 HSZ 401

Structural and magnetic properties of SBA-15 assisted Heusler nanowires and nanoparticles — •Changhai Wang, Jinfeng Qian, Paul Simon, Gerhard Fecher, and Claudia Felser — Max-Planck-Institut für Chemische Physik fester Stoffe

We report the first preparation of Heusler nanowires and nanoparticles with examples of Co2FeGa and Co2NiGa using SBA-15 silica as the templates. Structural probes using XRD and XAFS confirm the formation of L21 Co2FeGa Heusler phase. Magnetic dipole stray fields are observed for isolated Co2FeGa nanowires indicating multiple magnetic domains. The magnetic inductions of selected Co2FeGa nanowires are evaluated by the magnetic phase shift giving rise to intrinsic magnetic induction magnitude lying in the range 1.1 T. The particle size of Co2NiGa Heusler nanoparticles significantly affect their phase transition and magnetic properties. The scientific and technical implications of Heusler nanowires and nanoparticles in application fields such as spintronics and magnetic shape memory alloys are also discussed.

MA 10: Spin-dependent Transport Phenomena

Time: Monday 15:00–18:00 Location: HSZ 403

MA 10.1 Mon 15:00 HSZ 403

Anomalous Hall effect in Heusler alloys: native disorder and Fermi-sea term — •Josef Kudrnovsky[1], Ilja Turek[2], and Vaclav Drchal[1] — [1]Institute of Physics AS CR, Prague — [2]Institute of Physics of Materials AS CR, Brno

The anomalous Hall effect of selected Heusler alloys is estimated from first principles. An emphasis is put on the effect of the native disorder which is often present in the stoichiometric samples.

We employ a recently developed fully-relativistic Kubo-Streda approach adapted to disordered multisublattice systems in which the chemical disorder is described in terms of the coherent potential approximation. Both the Fermi-surface [1] and Fermi-sea [2] terms are included.

As case studies we choose half-metallic Heusler alloys Co2CrAl, Co2MnAl, and the spin gapless semiconductor alloy Mn2CoAl.

We demonstrate that a proper inclusion of the disorder significantly improves agreement between the experiment and theory. The importance of inclusion of the Fermi-sea term is also discussed.

[1] J. Kudrnovsky et al., Phys. Rev. B 88 (2013) 014422
[2] I. Turek et al., talk at this conference

MA 10.2 Mon 15:15 HSZ 403

ballistic emission electron microscopy investigation of the spin filtering effect in epitaxial Fe/Au/Fe/GaAs(001) spin valve — •marie hervé[1,2], sylvain tricot[1], yann claveau[1], sophie guézo[1], sergio di matteo[1], gabriel delhaye[1], bruno lépine[1], philippe schieffer[1], and pascal turban[1] — [1]Département Matériaux-Nanosciences - Institut de Physique de Rennes, Rennes, France — [2]Physikalisches Institut, Karlsruhe Institute of Technology (KIT),Karlsruhe, Germany

Ballistic Electron Magnetic Microscopy (BEMM) is a unique experimental tool allowing characterization of electronic properties of buried interfaces with nanometric lateral resolution. In BEMM experiments, hot electrons are injected from an STM tip into a spin-valve/semiconductor heterostructure. The measurement of the hot electron magnetocurrent collected at the back of the substrate gives access to the local magnetoconductance properties of the spin valve. In this communication, we will discuss experimental BEMM investigations on the epitaxial spin-valves Fe/Au/Fe/GaAs(001). In this structure, BEMM measurement show hot electron magnetocurrents as high as 500% at room temperature. This magnetocurrent is observed to be independant on the Fe layers thickness, and is thus dominated by interfacial effects [1]. We demonstrate that these strong magnetoconductance effects are related to the spin filtering effect at the gamma point that was predicted by Autès et al. [2]

[1] M. Hervé et al., Appl. Phy. Lett. 103 (2013) 202408 [2] G. Autès et al., Phys. Rev. B 83 (2011) 052403.

MA 10.3 Mon 15:30 HSZ 403

Generalized Wannier functions for an ab initio description of the electronic structure of chiral magnets — •Jan-Philipp Hanke, Frank Freimuth, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Complementary to delocalized Bloch functions, Wannier functions provide insight into the nature of crystal bonding and allow for simplified and accurate calculations of the electronic structure due to their spatial localization [1]. Here, we present the formalism of higher dimensional generalized Wannier functions (GWFs) which are obtained by Fourier transformations of Bloch functions that depend on reciprocal **k**-vector and additionally carry a dependence on the spin-spiral vector **q**. We implement the machinery for constructing such GWFs from ab initio within the full-potential linearized augmented-plane-wave code `FLEUR` [2]. Using this formalism, we acquire a minimal and very accurate description of the first-principles Hamiltonian in **k** and **q** space. Additionally, GWFs provide access to efficient calculation of exchange Heisenberg constants and transport properties of chiral magnets.

Financial support by the HGF-YIG Programme VH-NG-513 is gratefully acknowledged.

[1] N. Marzari and D. Vanderbilt, Phys. Rev. B **65**, 12847 (1997)
[2] See http://www.flapw.de

MA 10.4 Mon 15:45 HSZ 403

Transverse charge and spin transport within the Kubo-Bastin formalism — •Kristina Chadova, Diemo Ködderitzsch, and Hubert Ebert — Universität München, Department Chemie, Butenandtstr. 5-13, D-81377 München

In recent years several first-principles approaches have been established to treat transverse electron transport phenonmena as e.g. the anomalous Hall effect and spin Hall effect. Most of them treat particular contributions to the full conductivity tensor. We present a first-principle approach based on the Kubo-Bastin equation implemented withtin the fully relativistic KKR (Korringa-Kohn-Rostoker) formalism that is able to treat intrinsic and extrinsic contributions on equal footing. Both contributions from states below ("Fermi sea") and at the Fermi level ("Fermi surface") are treated and can be analysed with respect to constituting the full transverse conductivities. The approach is applicable to pure systems as well as metallic and semiconductor alloy systems. Several applications are presented that demonstrate the reliability and the power of the proposed scheme.

MA 10.5 Mon 16:00 HSZ 403

Perpendicular magnetic tunnel junctions with $Mn_{3-x}Ga$ bottom electrode — •Manuel Glas[1], Daniel Ebke[2], Eugen Schellenberg[1], Karsten Rott[1], Jan Schmalhorst[1], 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

The integration of $Mn_{3-x}Ga$ thin films with perpendicular magnetic anisotropy into magnetic tunnel junctions was investigated. MgO (001) and $SrTiO_3$ (001) substrates were used to achieve epitaxial (001)-oriented thin films. Crystallographic and magnetic measurements were performed to characterise the $Mn_{3-x}Ga$ electrodes. To overcome the lattice mismatch between the bottom electrode and the MgO barrier, a thin CoFeB interlayer was deposited. A magnetically perpendicular counter electrode was formed by Co/Pt multilayers. To improve the applicability, we replaced the Co/Pt multilayer by a perpendicularly magnetised CoFeB thin film. Additionally, CoFeB based perpendicular magnetic tunnel junction were investigated for comparison. Samples with Co/Pt counter electrode exhibited a TMR effect of only 3 % and samples with CoFeB top electrode showed an effect of 5 %. However, CoFeB based tunnel junctions revealed the highest MR effect with 72 %. The temperature dependent transport measurements of Mn-Ga based tunnel junctions with CoFeB counter electrode exhibited an initial increase of the TMR effect and a maximum effect between 80 and 100 K. For lower temperatures the TMR effect decreases, due to a reversal of the coercivity of both CoFeB electrodes.

15 min. break

MA 10.6 Mon 16:30 HSZ 403

First principles calculation of spin chirality contribution to thermoelectric transport effects — •Jürgen Weischenberg, Frank Freimuth, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

In magnetic systems with a non-collinear configuration of spins, the conduction electrons may acquire a geometrical phase, the so-called Berry phase, which gives rise to a topological contribution to the transverse current in response to an external field. In contrast to the anomalous Hall effect, which originates from the spin-orbit interaction (SOI), the topological contribution also exists in systems without SOI and in which the scalar spin chirality symmetry is non-zero. In this work, we take nano-skyrmionic lattices as such an example and study the influence of SOI on the topological contribution in the presence of an electric field or a temperature gradient. For this purpose, we compute the electronic properties of the spin texture in real space using density functional theory. We then employ the Wannier interpolation technique in order to examine the various thermoelectric transport coefficients within linear response.

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.

MA 10.7 Mon 16:45 HSZ 403

Emerging Magnetic Order in Pt atomic contacts and chains — •Florian Strigl, Christopher Espy, Maximilian Bückle, Torsten Pietsch, and Elke Scheer — Department of Physics, University of Konstanz, 78475 Konstanz, Germany

Platinum, as bulk metal, is not magnetically ordered, but it is a strong paramagnet close to the Stoner criterion of ferromagnetism. Several theoretical predictions exist about the formation of a magnetically ordered state in reduced dimensions and in particular in atomic chains [Smogunov, Thiess]. This makes it possible to study the influence of magnetic order on conductance properties of atomic contacts without influencing the contact geometry due to magnetostriction [Egle]. In this talk we will show results of a detailed experimental study in which we follow the evolution of magnetoconductance (MC) in atomic platinum contacts. The size, sign, and signature of single MC traces can vary largely even for slight changes on the contact and also show an anisotropic behavior. These features are similar to those found for atomic-size contacts of the 3d band magnets. We discuss how these findings may be put into context with a locally constricted magnetic order in the contact.

[Smogunov] Phys. Rev. B 78, 014423 (2008) [Thiess] Phys. Rev. B 81, 054433 (2010) [Egle] Phys. Rev. B 81, 134402 (2010)

MA 10.8 Mon 17:00 HSZ 403

Symmetry of spin transport coefficients — •Marten Seemann, Diemo Ködderitzsch, and Hubert Ebert — Universität München, Dept. Chemie, Butenandtstraße 5-13, D-81377 München, Germany

The symmetry of the coefficients appearing in the description of charge, spin and thermo transport is important when discussing experimental setups and theoretical calculations for ordered two- or three dimensional systems. Starting from Kubo's linear response theory, Kleiner [1] devised a scheme that provides the symmetry of transport coefficients for pairs of operators in perturbation/response providing generalized Onsager relations. We extended this scheme to describe the symmetry of conductivity tensors appearing in spin- and thermo-magneto-galvanic transport. Implications for the appearance of interesting effects described by non-zero elements of the respective conductivity tensors are outlined. Several examples (anomalous Hall and Nernst as well as spin Hall and Nernst conductivities) are given to illustrate this analysis in combination with numerical results obtained using the spin-polarized KKR electronic structure method.

[1] W. H. Kleiner, Phys. Rev. **142**, 318 (1966), *ibid.* **153**, 726 (1967)

MA 10.9 Mon 17:15 HSZ 403

Spin transport and magnetoresitance in metal | phthalocyanine | metal vertical heterostructures investigated by first principle methods — •Hahn Torsten — Institute for Theoretical Physics, TU Freiberg, D-09596 Freiberg

Based on density functional theory electronic structure calculations we used the nonequilibrium Green's function formalism (NEGF) to study finite bias quantum transport in metal | metal-phthalocyanine | metal heterostructures. The investigated structures model phthalocyanine layers sandwiched between two semi-infinite metal electrodes. We study the quantum transport and thus the magnetoresitance of such devices as a function of the applied bias voltage. By varying the type of the Phthalocyanine in the junction we show that one can tune the magnitude of the magnetoresistance. Furthermore we can show that even with the strong coupling between Phthalocyanine and metal electrodes it is possible to reach reasonable magnetoresistance values which could make those molecules suitable for prototypical spin-transport based devices.

MA 10.10 Mon 17:30 HSZ 403

Magnon-phonon dynamics in the heat transport in low dimensional quantum antiferromagnetic cuprates. — •Matteo Montagnese[1], Ekaterina Khadikova[2], Xenophon Zotos[3], Oleg Mityashkin[4], Christian Hess[4], Alexandre Revcolevschi[5], Romuald Saint-Martin[5], and Paul H M van Loosdrecht[1] — [1]II. Physikalisches Institut der Universität zu Köln, D-50937 Köln, Germany — [2]Zernike Institute for Advanced Materials, Rjiksuniversiteit Groningen, Groningen, Tmohe Netherlands — [3]Department of Physics, University of Crete and Foundation for Research and Technology-Hellas, 71003 Heraklion, Greece — [4]IFW-Dresden, Institute for Solid State Research, D-01171 Dresden, Germany — [5]Laboratoire de Physico-Chimie de L'Etat Solide, ICMMO, UMR8182, Université Paris-Sud, 91405 Orsay CEDEX, France

Low dimensional cuprate antiferromagnets such as the spin chain SrCuO2 and the spin ladder Ca9La5Cu24O41 are notable for their quantum disordered ground state and their intriguing magnetic excitation spectrum . Moreover, they show an unusual magnon-dominated thermal conduction over a wide temperature range, partly due to extremely long magnetic mean free paths, eventually in the micron range. At the same time, space and time-resolved optics is emerging as an optimal tool to probe thermal transport at the microscale. We have applied different space- and time-resolved optical methods to study the magnetic thermal transport dynamic, aiming at detecting its ballistic component and clarifying the kinetics and interaction of AFM excitations in low dimensions.

MA 10.11 Mon 17:45 HSZ 403

Superconducting proximity effect and zero-bias anomaly in quantum dots weakly attached to ferromagnetic leads — •Piotr Trocha and Ireneusz Weymann — Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznan, Poland

The Andreev transport through a quantum dot coupled to two external ferromagnetic leads and one superconducting lead is studied theoretically by means of the real-time diagrammatic technique in the sequential and cotunneling regimes. We show that the tunnel magnetoresistance (TMR) of the Andreev current displays a nontrivial dependence on the bias voltage and the level detuning, and can be described by analytical formulas in the zero temperature limit. The cotunneling processes lead to a strong modification of the TMR, which is most visible in the Coulomb blockade regime. We find a zero-bias anomaly of the Andreev differential conductance in the parallel configuration, which is associated with a nonequilibrium spin accumulation in the dot triggered by Andreev processes.

MA 11: Magnetic Heuslers, Half-metals and Oxides II (with TT)

Time: Monday 15:00–18:45 Location: BEY 118

Invited Talk MA 11.1 Mon 15:00 BEY 118
Design principles of Dirac fermions and Mott insulating states in (111) oriented perovskite superlattices — •Rossitza Pentcheva — Ludwig Maximilians University, Munich, Germany

Oxide interfaces exhibit a broad spectrum of functional properties that are not available in the respective bulk compounds, such as two-dimensional conductivity, superconductivity and magnetism. With their distinct topology, (111) perovskite superlattices promise to host even more exotic electronic states compared to the much studied (001)-oriented systems. Material-specific density functional theory calculations with an on-site Coulomb repulsion term are used to explore the role of confinement, symmetry breaking, polarity mismatch and strain in the emergence of novel phases. The results illuminate a rich set of competing ground states in $(LaAlO_3)_M/(SrTiO_3)_N(111)$ [1] and $(LaNiO_3)_N/\ (LaAlO_3)_M(111)$ superlattices, ranging from spin-polarized, Dirac-point Fermi surfaces to charge-ordered Mott or Peierls insulating phases. Orbital reconstructions and metal-to-insulator transitions depend critically on the thickness of the quantum well N and in-plane strain, thus opening avenues for engineering properties at the nanoscale. Research in collaboration with D. Doennig and W.E. Pickett, supported by the DFG, SFB/TR80. [1] D. Doennig, W. E. Pickett, and R. Pentcheva, Phys. Rev. Lett. **111** 126804 (2013).

15 min. break

MA 11.2 Mon 15:45 BEY 118
Giant Verwey transition in magnetite thin films — Mehrdad Baghaie Yazdi and •Lambert Alff — Institut für Materialwissenschaft, TU Darmstadt

The Verwey transition in magnetite is an enigmatic challenge of solid state physics since several decades. It is generally believed that the change in magnetic moment at the Verwey transition is due to a change in magnetocrystalline anisotropy and spin reorientation. In thin films of magnetite with extraordinary high Verwey transition at 128 K, we have observed a giant change of magnetic moment above 1000%. Using several methods including neutron reflectometry we rule out spin reorientation as the origin of our observation. In addition, Raman scattering experiments show that the structural phase transition occurs at temperatures above the magnetic Verwey transition while, in contrast, newly emerging modes indicating additional charge and orbital order appear only at the Verwey transition. This result suggests that the structural phase transition in magnetite is a necessary precursor triggering a transition into a complex charge and orbitally ordered state.

MA 11.3 Mon 16:00 BEY 118
$NiFe_2O_4$: a candidate for efficient spin filtering at room temperature? — •Michael Hoppe[1], Sven Döring[1], Mihaela Gorgoi[3], Felix Gunkel[4], Claus M. Schneider[1,2], and Martina Müller[1,2] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich — [2]Fakultät für Physik, Universität Duisburg-Essen — [3]BESSY II, Helmholtz-Zentrum Berlin für Materialien und Energie — [4]Peter-Grünberg-Institut (PGI-7), Forschungszentrum Jülich

For the optimized performance of spintronic devices, one major challenge is to create highly spin-polarized electron currents. One promising approach is the usage of both insulating and magnetic tunnel barriers, with a highly spin-dependent tunneling probability. For this purpose, the spinel ferrite $NiFe_2O_4$ (NFO) is a very auspicious material since it shows both features even at room temperature.
To realize magnetic tunnel junctions, it is necessary to grow NFO films ($d < 5$ nm) which maintain quasi bulk-like properties down to this ultrathin film limit. Therefore, NFO films with varying thickness between 2 and 20 nm are deposited on Nb-doped $SrTiO_3$ substrates via pulsed laser deposition. HAXPES, XRD and XANES measurements reveal them to be chemically and structurally comparable to the bulk material. XMCD studies of the Ni- and Fe-L-edges in those films show that the alignment of the magnetic moments carried by these elements is preserved for all thicknesses. The insulating behavior is confirmed by CFM measurements. On this basis, we fabricated Nb:STO/NFO/Au tunnel junctions by means of optical lithography and characterized their electrical transport properties.

MA 11.4 Mon 16:15 BEY 118
Combined theoretical and optical band gap determination of NiFe2O4 and CoFe2O4 — •Markus Meinert and Günter Reiss — Center for Spinelectronic Materials and Devices, Bielefeld University, Germany

In a theoretical study we investigate the electronic structure and the band gap of the inverse spinel ferrites $NiFe_2O_4$ (NFO) and $CoFe_2O_4$ (CFO). The experimental optical absorption spectrum of NFO is well reproduced by fitting the Tran-Blaha parameter in the modified Becke-Johnson (mBJLDA) potential. For CFO, the agreement is less satisfying. The accuracy of the commonly applied Tauc plot to find the optical gap is assessed based on the computed spectra and we find that this approach can lead to a misinterpretation of the experimental data.

The minimum gap of $NiFe_2O_4$ is found to be a 1.53 eV wide indirect gap, which is located in the minority spin channel. In $CoFe_2O_4$, the band gap is about 0.9 eV wide and is also located in the minority spin channel.

MA 11.5 Mon 16:30 BEY 118
Exploring spin-filter tunneling in single-crystalline magnetic oxide heterostructures — •Bernardus Zijlstra[1], Patrick Lömker[1], Christian Caspers[1], Michael Hoppe[1], Jürgen Schubert[2], Willi Zander[2], Mihaela Gorgoi[3], Claus M. Schneider[1], and Martina Müller[1] — [1]Peter Grünberg Institute (PGI-6), Forschungszentrum Jülich — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich — [3]BESSY II, Helmholtz-Zentrum Berlin

Magnetic insulators, like Europium Oxide (EuO) are of tremendous interest for spintronic research, since they can generate highly spin-polarized currents. In contrast to conventional tunneling, spin-filter tunneling through single-crystalline magnetic insulator barriers is not yet fully understood.

In order to realize fully epitaxial magnetic oxide tunnel barriers, ultrathin EuO films were grown directly on conductive Sn-doped In_2O_3 (001) (ITO), Nb-doped $SrTiO_3$ (001) (STO) and As-doped Si (001).

The EuO heteroepitaxy was characterized by LEED, RHEED and XRD, whereas the magnetic and chemical properties were analyzed by SQUID and hard x-ray photoelectron spectroscopy. We find EuO/Si(001) and EuO/STO(001) to be epitaxial, stoichiometric and to display bulk-like magnetic properties, however, EuO/ITO(001) is strongly affected by oxygen diffusion at elevated T_S. Electrical transport experiments reveal the respective spin filter tunneling properties.

MA 11.6 Mon 16:45 BEY 118
Direct observation of half metallicity in the Heusler compound Co2MnSi — •Martin Jourdan[1], Alexander Kronenberg[1], Jan Minar[2], Michaela Kolbe[1], Andrey Gloskovskij[3], Gerd Schönhense[1], Hans Joachim Elmers[1], Stanislav Chadov[4], Claudia Felser[4], and Mathias Kläui[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]Department Chemie und Biochemie, Ludwig-Maximilians-Universität München — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg — [4]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden

Heusler compounds are in the focus of interest due to their predicted half-metallic properties, which makes them highly interesting for spintronics. Apart from applications those materials are a test for modern band structure calculations for materials with electronic correlations of medium strength. Although a large body of those calculations is available, their experimental verification remains a major task. Here epitaxial thin films of the compound Co2MnSi are investigated in-situ by UV-photoemission spectroscopy (UPS) taking advantage of a novel multi-channel spin filter. An exceptionally large spin polarization of 93% is obtained at room temperature, providing strong direct evidence for half-metallicity. The energy dependencies of the measured spin polarization as well as of spin integrated UPS essentially agree with bulk band structure calculations. Additional ex-situ spin integrated hard x-ray photoemission spectroscopy experiments (HAXPES) corroborate that indeed bulk states are observed by SRUPS.

15 min. break

MA 11.7 Mon 17:15 BEY 118

Spin dependent lifetimes and non-degenerate spin hot spots in Heusler compounds — •Steffen Kaltenborn and Hans Christian Schneider — Physics Department and Research Center OPTIMAS, University of Kaiserslautern

We present results of an accurate ab-initio calculation of the dielectric function of the half-metallic Heusler compounds Co_2MnSi and Co_2FeSi. The numerical method is based on density functional theory [1,2] in combination with a wave-vector dependent linear tetrahedron method [3]. The dielectric function is used study optical, acoustic and intraband plasmon dispersions in these half metals. As in the case of simple metals, a negative intraband plasmon dispersion [3] is found. Furthermore, we use the dielectric function to analyze the **k** and spin-resolved electronic lifetimes in these materials. Qualitatively, the lifetimes reflect the lineup of electron and hole bands. We determine the spin-flip and spin-conserving contributions to the lifetimes and predict that different excitation conditions may lead to different spin-flip dynamics of excited electrons and may even give rise to an enhancement of the non-equilibrium spin polarization. Finally, we study in detail the behavior of the lifetimes around states that are strongly spin mixed by spin-orbit coupling. We find that, for non-degenerate bands, the spin mixing alone does not determine the energy dependence of the (spin-flip) lifetimes.
[1] DFT-Program The Elk FP-LAPW Code, http://elk.sourceforge.net. [2] C. Ambrosch-Draxl et al., Comp. Phys. Commun. **175**, 1-14, (2006). [3] S. Kaltenborn and H. C. Schneider, Phys. Rev. B **88**, 045124 (2013).

MA 11.8 Mon 17:30 BEY 118

NMR Investigation of Optimal Mn Content in $Co_2Mn_xSi_{0.88}$ Thin Films for High Tunneling Magneto-Resistance — •Steven Rodan[1], Tomoyuki Taira[2], Masafumi Yamamoto[2], Bernd Büchner[1,3], and Sabine Wurmehl[1,3] — [1]Leibniz Institute for Solid State and Materials Research, 01171 Dresden, Germany — [2]Division of Electronics for Informatics, Hokkaido University, Sapporo 060-0814, Japan — [3]Institute für Festkörperphysik, Technische Universität Dresden, D-01062 Dresden, Germany

Half-metallic ferromagnets (HMFs), with 100% spin-polarized conduction electrons, are prime candidates for developing spintronics devices. Many Heusler compounds, such as Co_2MnSi, are predicted to be HMFs. A technique for probing local structure such as nuclear magnetic resonance (NMR) is essential for understanding the microscopic origin of manifested physical properties. Local atomic disorder was investigated using both ^{59}Co and ^{55}Mn NMR on epitaxial films of $Co_2Mn_xSi_{0.88}$, with varying Mn content (x = 0.72, 1.12, 1.32). NMR spectra confirmed that the high tunneling magneto-resistance ratio values for magnetic tunnel junctions with electrodes made from highest Mn excess (x=0.32), can be attributed mainly to the reduction of Co antisites (Co on Mn and/or Si sites), which are expected to strongly decrease the half-metallicity.

MA 11.9 Mon 17:45 BEY 118

Evolution of the coercive field of Co_2FeGa Heusler nanocrystals and related oxide nanoparticles inside carbon nanotubes — •Markus Gellesch[1], Usue Palomares Iñiguez de Ciriano[1], Changhai Wang[2], Sabine Wurmehl[1], Silke Hampel[1], and Bernd Büchner[1] — [1]Leibniz Institut für Festkörper- und Werkstoffforschung Dresden — [2]Max-Planck-Institut für Chemische Physik fester Stoffe, 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 magnetic properties of Heusler nanoparticles and related oxide materials prepared inside multi-walled carbon nanotubes via a wet-chemical approach. While previous studies[1] already showed, that the coercive field of the Heusler nanocrystals inside carbon nanotubes is enhanced by a factor of at least 30, we now report of an enhancement factor of approximately 100 in Co_2FeGa nanoparticles and of coercive fields as large as 6000 Oe in related oxide materials. Further we present results of the diameter dependence of the coercive field in the later material. The results of our work open the door for the exploration of Heusler and related magnetic materials at the nanoscale and also guide the way to the synthesis of nanomaterials with tailored physical properties.
[1] Gellesch et al., Cryst. Growth Des., 2013, 13 (7), pp 2707–2710

MA 11.10 Mon 18:00 BEY 118

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], Hans-Joachim Grafe[1], Bernd Büchner[1], Sabine Wurmehl[1], Stefan Martin[2], Volker Klemm[2], and David Rafaja[2] — [1]Leibniz-Institute for Solid State and Materials Research, Dresden, Germany — [2]TU Bergakademie Freiberg, Germany

In this work, we studied the intrinsic properties of the Heusler compound Fe_2VAl and the influence of p (V substituted by Ti)- and n-doping (Al substituted by Si) on the intrinsic materials properties using single crystals. Electron back scattering diffraction reveals the presence of a V-rich secondary ferromagnetic phase in particular in crystals with Si and in the parent compound, which could be further confirmed by TEM investigations. The depletion of V from the Fe_2VAl matrix apparently leads to localized Fe moments and also to magnetic order in the corresponding samples. The evolution of magnetic order and thermoelectric key parameters were further analysed by means of nuclear magnetic resonance, transport and magnetization measurements. Interestingly, the sample with Ti and less V depletion shows a significant enhancement of the figure of merit compared to the other samples.

MA 11.11 Mon 18:15 BEY 118

Effect of high pressures synthesis on $Ba_3YIr_2O_9$ — •Hannes Stummer, Tusharkanti Dey, Sabine Wurmehl, and Bernd Büchner — Leibniz-Institute for Solid State and Materials Research Dresden, Germany

The emergent field of Iridium oxide based materials recently came into focus due to their variety of interesting physical properties, specifically the new and unknown combinations of magnetic properties with interesting ground states [1]. These fascinating phenomena are induced by interaction of large Spin-Orbit-Coupling of the 5d transition metal and the onsite Coulomb energy U. Recent investigations of the Iridate $Ba_3YIr_2O_9$ show that sample grown under normal pressure crystallize in a hexagonal structure and exhibit magnetic ordering below 4 K [2]. The crystal structure is transformed to a cubic double perovskite configuration (stable at ambient pressure), when treated at 8 GPa pressure. In this cubic double perovskite phase the magnetic ordering is suppressed. A possible spin-orbit driven spin liquid ground state is proposed for the high pressure perovskite structure [3]. We will present recent results about the systematic high pressure synthesis of $Ba_3YIr_2O_9$ samples grown under different growth pressure in a Multi-Anvil assembly.The main focus will be on the measurements of structural and magnetic properties depending on the applied pressure during the synthesis process. [1] B. J. Kim et al., Phys. Rev. Lett. 101, 076402 (2008) [2] Y. Doi et al., J. Phys.: Condens. Matter 16, 2849 (2004) [3] T. Dey et al., Phys. Rev. B 88, 134425 (2013)

MA 11.12 Mon 18:30 BEY 118

Pressure-tuning of the magnetic properties of the zero-field cooled exchange-bias Heusler compound Mn_2PtGa — •Catalina Salazar, Ajaya K. Nayak, Claudia Felser, and Michael Nicklas — Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany

The Heusler compound Mn_2PtGa crystallizes in a tetragonal structure at room temperature. It undergoes a paramagnetic to ferrimagnetic (FI) transition around T_c=230 K followed by a first-order ferrimagnetic to antiferromagnetic (AFM) transition at lower temperature. The most intriguing feature observed in Mn_2PtGa is, however, a large zero-field cooled exchange bias. Here, we present a study of the pressure evolution of the magnetic properties of the Mn_2PtGa Heusler alloy by magnetization measurements under hydrostatic pressures up to 1.2 GPa.

MA 12: Topological insulators: mostly interaction with magnetic fields (with HL/O/TT)

Time: Monday 15:45–17:45 Location: POT 081

MA 12.1 Mon 15:45 POT 081

SQUID devices built form S-TI-S junctions based on mercury telluride (HgTe) — •Luis Maier, Manuel Grimm, Christopher Armes, Christoph Brüne, Hartmut Buhmann, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, 97074 Würzburg

In the search for Majorana fermions, one way to show their existence requires an interface of a s wave superconductor and a strong topological insulator (TI) [1]. It has already been shown, that a three-dimensional, strained layer of HgTe shows dominant surface conductance in magnetotransport measurements and thus is considered as a 3D-TI [2]. Here we investigate the interaction of superconducting contacts with Dirac Fermions.

S-TI-S junctions based on HgTe and Nb have already been fabricated and characterized successfully [3]. As a next step in this research we created SQUID structures to further study the current phase relation in these special devices. In this talk we are going to present our recent results searching for deviations from normal behaviour that could point to TI or Majorana interactions.

[1] L. Fu and C. L. Kane, Phys. Rev. Lett. 100, 096407 (2008)
[2] C. Brüne et al., Phys. Rev. Lett. 106, 126803 (2011)
[3] J. Oostinga et al., Phys. Rev. X 3, 021007 (2013)

MA 12.2 Mon 16:00 POT 081

Quantum Interferences of Dirac fermions in Bi2Se3 nanostructures — •Louis Veyrat, Joseph Dufouleur, Romain Giraud, Hannes Funke, Silke Hampel, Christian Nowka, Joachim Schumann, and Bernd Büchner — IFW-Dresden, Dresden, Germany

Recently discovered Z2 topological insulators (TIs) are ideally conducting at their interface only, where a gapless band structure forms. In a strong 3D TI, such as Bi2Se3, surface states are spin-chiral Dirac fermions with an odd number of Dirac cones. However, in real materials, the finite bulk conductivity often prevents the study of surface-state transport. We show that mesoscopic transport measurements can unambiguously reveal the specific properties of spin-chiral Dirac fermions in a Bi2Se3 nanostructure [1]. The quantum conductance of a nanowire exhibits Aharonov-Bohm oscillations which result only from surface-state transport. At very low temperatures, the temperature dependence of their amplitude unveils the quasi-ballistic nature of charge transport, which is the signature of the weak coupling of quasi-particles to their environment. Our results further reveal the weak scattering by structural disorder, giving another evidence of the specific nature of spin-chiral Dirac fermions in a strong 3D TI. Furthermore, new physics evidenced in the study of UCF in a nanowire, could be the signature of a perfectly transmitted mode in a nanowire geometry [2].

[1] J. Dufouleur et al., Phys. Rev. Lett. 110, 186806 (2013)
[2] J. Bardarson et al., Phys. Rev. Lett. 105, 156803 (2010)

MA 12.3 Mon 16:15 POT 081

Thermal and Electrical Transport of Single-Crystalline Bismuth Telluride Nanowires — •Bacel Hamdou[1], Johannes Kimling[1], Johannes Gooth[1], August Dorn[1], Eckhard Pippel[2], Raimar Rostek[3], Peter Woias[3], and Kornelius Nielsch[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Max Planck Institute of Microstructure Physics, Halle, Germany — [3]Department of Microsystems Engineering, University of Freiburg, Germany

Bi_2Te_3 is a topological insulator (TI), a phase of matter that has a bulk bandgap and gapless electronic surface states protected by time-reversal symmetry. Studying topological surface states via electrical transport measurements is still very difficult due to large bulk contribution to conductivity originating from unintentional doping and the small bulk band gaps, which are typical for TI materials. We report on thermal and electrical transport measurements on individual single-crystalline bismuth telluride nanowires (NWs), synthesized via catalytic growth and post-annealing in a Te-rich atmosphere. The resulting Bi_2Te_3 NWs show reproducible electronic transport properties that are close to those of intrinsic bulk Bi_2Te_3. Further, magnetoresistance measurements were performed at temperatures down to 2 K. The parallel magnetoresistance curves exhibit Aharonov-Bohm oscillations, which indicate the presence of topological surface states. Analyses of Subnikov-de Haas oscillations in perpendicular magnetoresistance yield extremely low two-dimensional carrier concentrations and effective electron masses, and very high carrier mobilities.

MA 12.4 Mon 16:30 POT 081

Ambipolar quantum Hall effect in strained bulk HgTe — •Cornelius Thienel, Jonas Wiedenmann, Steffen Wiedmann, Christoph Brüne, Christopher Ames, Hartmut Buhmann, and Laurens W. Molenkamp —
Universität Würzburg, Experimentelle Physik III

Strained bulk HgTe has been identified as three-dimensional topological insulator [Phys. Rev. Lett. **106**, 126803 (2011)]. A Dirac-specific quantum Hall sequence can unambiguously be demonstrated in transport measurements. Furthermore we identify two subsets of Landau levels that originate from the topological surface states.
Improving the quality of the interfaces hosting the surface states by introducing additional buffer and cap layers to the structure increases the carrier mobilities in the topological states and makes it possible to observe the quantum Hall effect of electrons and holes in a wide gate voltage range. The detection of p-type QHE points towards a suppressed interaction between bulk and surface states.

MA 12.5 Mon 16:45 POT 081

Weak antilocalization effects in systems with Dirac-like energy dispersion — •Andreas Budewitz, Mathias Mühlbauer, Bastian Büttner, Grigory Tkachov, Ewelina M. Hankiewicz, Christoph Brüne, Hartmut Buhmann, and Laurens W. Molenkamp — Universität Würzburg, Lehrstuhl für experimentelle Physik III

HgTe quantum wells (QW) have been identified as topological insulator (TI) by appearence of the QSHE [1]. It has been shown that the band structure of HgTe QWs has to be described by a four band model revealing a Dirac like dispersion [2, 3]. Here now we investigate the weak antilocalization (WAL) effect in various n-conducting HgTe QWs. We analyse the magnetoresistance of a set of quasi one-dimensional wires and clearly observe different WAL amplitudes for normal and inverted band ordering which does not depended on the structural inversion asymmetry (SIA). The data demonstrate that a non-universal Berry phase which exceeds π, the characteristic value for gapless Dirac fermions, is needed to explain the different observations in our measurements.

[1] M. König, S. Wiedmann, C. Brüne, A. Roth, H. Buhmann, L. W. Molenkamp, X.-L. Qi and S.-C. Zhang, Science 318, 766 (2007)
[2] B. A. Bernevig, T. L. Hughes and S. C. Zhang, Science 318, 1757 (2006)
[3] B. Büttner, C.-X. Liu, G. Tkachov, E. G. Novik, C. Brüne, H. Buhmann, E. M. Hankiewicz, P. Recher, B. Trauzettel, S.-C. Zhang, and L. W. Molenkamp, Nature Phys. 7, 418 (2011)

MA 12.6 Mon 17:00 POT 081

Giant Photocurrents in a Dirac Fermion System at Cyclotron Resonance — •C. Zoth[1], P. Olbrich[1], P. Vierling[1], K.-M. Dantscher[1], G.V. Budkin[2], S.A. Tarasenko[2], V.V. Bel'kov[2], D.A. Kozlov[3], Z.D. Kvon[3], N.N. Mikhailov[3], S.A. Dvoretsky[3], and S.D. Ganichev[1] — [1]Terahertz Center, Regensburg, Germany — [2]Ioffe Institute, St. Petersburg, Russia — [3]Institute of Semiconductor Physics, Novosibirsk, Russia

We report on the observation of giant photocurrents in HgTe/HgCdTe quantum wells (QW) of critical thickness at which a Dirac spectrum emerges [1]. Exciting QW of 6.6 nm width by terahertz radiation and varying an external magnetic field we detected a resonant photocurrent. Remarkably, the position of the resonance can be tuned from negative (-0.4 T) to positive (up to 1.2 T) magnetic fields by means of optical doping. The photocurrent data, accompanied by measurements of radiation transmission, as well as, magnetotransport, prove that the photocurrent is caused by cyclotron resonance in a Dirac fermion system. This allows us to obtain the effective electron velocity $v \approx 7.2 \times 10^5$ m/s. We develop a microscopic theory of the effect and show that the inherent spin-dependent asymmetry of light-matter coupling in the system of Dirac fermions causes the electric current to flow.

[1] P. Olbrich, C. Zoth, P. Vierling *et al.*, *PRB* **87**, 235439 (2013)

MA 12.7 Mon 17:15 POT 081

Quantum Oscillations of Photogalvanic Effect and Spin Orbit Interaction Effect in HgTe Quantum Wells — •K.-M. Dantscher[1], C. Zoth[1], P. Olbrich[1], V.V. Belkov[2], M.A. Semina[2], M.M. Glazov[2], L.E. Golub[3], D.A. Kozlov[3], Z.D. Kvon[3], N.N. Mikhailov[3], S.A. Dvoretsky[3], and S.D. Ganichev[1] — [1]University of Regensburg, Regensburg, Germany — [2]Ioffe Institute, St. Petersburg, Russia — [3]Institute of Semiconductor Physics, Novosibirsk, Russia

We report on the observation of quantum oscillations in HgTe/HgCdTe quantum well (QW) structures of different widths, which are characterized by an inverted, normal and even Dirac like bandstructure [1,2]. Exciting the QWs by terahertz radiation and sweeping an external magnetic field we observed a resonant photocurrent [3] which shows pronounced oscillations. The photocurrent data are accompanied by measurement of photoconductivity, radiation transmission, as well as, magneto-transport. A comparison of the results shows that the photosignal is enhanced at cyclotron resonance position and is modulated by Shubnikov-De Haas oscillations. Furthermore we present a microscopic model of a magnetic field dependent oscillating current taking into account the oscillations of spin polarization and of conductivity.

[1] Z.D. Kvon *et al.*, *JETP Letters* **94**, 816-819 (2011)
[2] A. Bernevig *et al.*, *Science* **314**, 1757 (2006)
[3] P. Olbrich *et al. Phys. Lett B* **87**, 235439 (2013)

MA 12.8 Mon 17:30 POT 081

Strong Out-of-Plane Magnetic Anisotropy of Fe Adatoms on Bi_2Te_3 — •Thomas Eelbo[1], Marta Waśniowska[1], Marcin Sikora[2], Michal Dobrzański[2], Andrzej Kozlowski[2], Artem Pulkin[3], Gabriel Autès[3], Ireneusz Miotkowski[4], Oleg Yazyev[3], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Krakow, Poland — [3]Institute of Theoretical Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland — [4]Department of Physics, Purdue University, West Lafayette, USA

Topological insulators (TIs) are currently in the focus of fundamental physics. The interaction of magnetic impurities with TIs is widely unexplored on the local scale and might potentially entail interesting properties of the TIs in view of applications in spintronics. To this end, we studied the structural, electronic, and magnetic properties of individual Fe atoms adsorbed on a $Bi_2Te_3(111)$ surface by means of scanning tunneling microscopy/spectroscopy (STM/STS), X-ray absorption spectroscopy and X-ray magnetic circular dichroism (XMCD) at low temperatures. STM reveals the existence of two different Fe species. Density functional theory-based calculations let us assign these to atoms adsorbed on the fcc/hcp hollow sites. STS proves the existence of characteristic resonances for each type and XMCD evidences a strong magnetic out-of-plane anisotropy of the Fe moments in agreement with our calculations.

MA 13: PhD Symposium: Magnon Plasmonics (with jDPG)

Organizers: Th. Meyer, P. Melchior, M. Rollinger, Ph. Thielen (TU Kaiserslautern)

This symposium intends to bring researchers from both research fields in contact and trigger new cooperations and future research projects in the field of Magnon-Plasmonics. In order to merge both research fields, the symposium will start off with an introductory talk presenting the basics of both fields and developing a common basis for the following talks. This introduction is given by Prof. Robert Stamps (University of Glasgow). Prof. Dirk Grundler (University of Technology München) is going to give an invited talk about spin waves in artificial ferromagnetic materials, i.e. two-dimensional magnonic crystals. Afterwards, Dr. Antonio García-Martín (Instituto de Microelectronica de Madrid) will present a theoretical overview of the field of Magneto-Plasmonics, followed by Dr. Alexandre Dmitriev (Chalmers University of Technology Göteborg) presenting his experimental work on magneto-plasmonics and nanoplasmonics. Finally, an invited talk on ultrafast dynamics in magneto-plasmonic multilayer structures will be held by Dr. Vasily Temnov (Université du Maine, Le Mans).

Time: Tuesday 9:30–15:45 Location: HSZ 04

Topical Talk MA 13.1 Tue 9:30 HSZ 04

Plasmons & Magnons: Collective excitations of charge and spin — •Robert Stamps — SUPA School of Physics and Astronomy, University of Glasgow, Glasgow, UK

An overview of basic concepts essential for understanding GHz and THz excitations in magnetic spin and plasmonic systems will be presented. The talk will provide an introduction to spin waves in magnetic insulators and metals. Methods of generating and detecting magnetic spin excitations will be surveyed, and the interaction of optical light with magnetic materials will be discussed. A similar overview of how plasmons propagate in films and at surfaces will be presented, including a summary of how plasmons can be excited and observed. Lastly, some of the issues involved in considering possibilities for plasmon-magnonics will be highlighted and reviewed.

Topical Talk MA 13.2 Tue 10:15 HSZ 04

Nanomagnonics - reprogrammable wave control beyond plasmonics — •Dirk Grundler — Lehrstuhl fuer Physik funktionaler Schichtsysteme, Physik Department, TU Muenchen, Garching, Germany

Periodically nanopatterned thin-film ferromagnets have been shown to form magnonic crystals (MCs) [1], i.e., artificial crystals exhibiting tailored band structures for spin waves (magnons). In the GHz frequency regime, wave lengths of spin waves (SWs) are shorter by a few orders of magnitude compared to electromagnetic waves at the same frequency. At the same time unit cells of periodic magnetic lattices can exhibit different non-volatile remanent configurations leading to both reconfigurable band structures [2] and metamaterials properties for SWs [3] not known from photonics or plasmonics. MCs thereby offer a further approach for wave control in solid-state devices on the nanoscale. We show reprogrammable magnonic properties that might fuel further ideas when plasmonics meets magnonics.

Parts of the research have received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement No. 228673 MAGNONICS and No. 247556 NoWaPhen, the DFG project GR1640/5-1 in SPP 1538 and the German Excellence Cluster 'Nanosystems Initiative Munich (NIM)'.

[1] S. A. Nikitov, P. Tailhades, and C. S. Tsai, J. Magn. Magn. Mater. 236, 320 (2001). [2] J. Topp, D. Heitmann, M. Kostylev, and D. Grundler, Phys. Rev. Lett. 104, 207205 (2010). [3] R. Huber et al., Appl. Phys. Lett. 102, 012403 (2013).

MA 13.3 Tue 10:45 HSZ 04

Plasmonic excitations in permalloy wires imaged by XPEEM — •Ahmet Akin Ünal[1], Judith Kimling[2], Sergio Valencia[1], and Florian Kronast[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Strasse 15, D-12489 Berlin, Germany — [2]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung Hamburg, Universität Hamburg, Jungiusstrasse 11, D-20355 Hamburg, Germany

We investigate the influence of surface plasmon resonances in laser-excited gold nanoantennas on the demagnetization of neighboring magnetic microstructures. At metal surfaces, electromagnetic waves and light waves can couple with each other, forming surface plasmons (SP). A gold nanoantenna can be regarded as a resonator for SPs. In the case of resonant excitation, the oscillation amplitudes of the plasmon waves can overcome the excitation amplitude by orders of magnitude giving rise to a strong enhancement of the local electromagnetic field. Here, we investigate this local field effect of the plasmonic antennas on the neighboring permalloy microstructures, specifically on their magnetization dynamics. Permalloy (Ni0.81Fe0.19) microstructures and gold antennas were prepared by e-beam lithography on a Si(110) substrate. We studied the switching as function of laser polarization and power and we find that the laser power threshold, above which switching occurs, is much lower for structures with antennas than for reference structures without antennas next to them. This allows us to quantify the effect of the plasmonic antennas in each structure and compare it to plasmonic wave fields imaged by PEEM.

MA 13.4 Tue 11:00 HSZ 04

Tuning of the transverse magneto-optical Kerr effect in magneto-plasmonic crystals — •L.E. Kreilkamp[1], M. Pohl[1], V.I. Belotelov[2,3,4], I.A. Akimov[1], A.N. Kalish[2,3,4], N.E. Khokhlov[2,3], V.J. Yallapragada[5], A.V. Gopal[5], M. Nur-E-Alam[6], M. Vasiliev[6], D.R. Yakovlev[1], K. Alameh[6], A.K. Zvezdin[3,4,7], and M. Bayer[1] — [1]Experimentelle Physik 2, TU Dortmund, D-44221 Dortmund, Germany — [2]Lomonosov Moscow State University, 119991 Moscow, Russia — [3]Russian Quantum Center, 143025 Moscow, Russia — [4]Prokhorov General Physics Institute, Russian Academy of Sciences, 119991 Moscow, Russia — [5]Tata Institute of Fundamental Research, 400005 Mumbai, India — [6]Electron Science Research Institute, Edith Cowan University, 6027 Joondalup, WA, Australia — [7]Moscow Institute of Physics and Technology (State University), 141700, Dolgoprudny, Russia

Spectral properties of the transverse magneto-optical Kerr effect (TMOKE) in periodic metal-dielectric hybrid structures are studied, in particular with respect to the achievable magnitude. It is shown that the TMOKE is sensitive to the magneto-optical activity of the bismuth-substituted rare-earth iron garnet, which is used as dielectric material. For samples with larger Bi substitution level and, consequently, larger gyration constant, the magnitude of the TMOKE increases and reaches 13% in the case of a $Bi_{1.8}$ $Lu_{1.2}Fe_{3.6}Al_{1.4}O_{12}$ magnetic film. Further, it is demonstrated that the TMOKE vanishes at the high-symmetry points of the Brillouin zone (at the γ and X points). The role of different surface plasmon polaritons is discussed.

15 min. break

Topical Talk MA 13.5 Tue 11:30 HSZ 04

Basic concepts of magneto-plasmonics illustrated with an exactly solvable system — •Antonio García-Martín, Gaspar Armelles, Alfonso Cebollada, and Maria U. Gonzalez — IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), Issac Newton 8, PTM, E-28760 Tres Cantos, Madrid, Spain

In this talk I will give a brief introduction about the concept of magneto-plasmonics (our perspective). That will be followed by a discussion on the relevant materials or combinations. To finish we will focus on a simple example of an exactly solvable (analytic) system for coupled localized magneto-optically active plasmons, that will be compared with a, very illustrative, analog based on classical oscillators.

MA 13.6 Tue 12:00 HSZ 04

Control of light emission with magneto-optical particles — •Nuno de Sousa[1], Luis S. Froufe-Perez[2], and Antonio Garcia-Martin[3] — [1]Dept. Fisica de la Materia Condensada, Universidad Autonoma de Madrid, E-28049 Madrid, Spain — [2]Instituto de Estructura de la Materia, CSIC, Serrano 121, E-28006 Madrid, Spain — [3]IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), Issac Newton 8, PTM, E-28760 Tres Cantos, Madrid, Spain

The possibility of creating and manipulate nanostructured materials encouraged the exploration of new strategies to control the electromagnetic properties with an external agent. A possible approach is combining magnetic and plasmonic materials, where it is feasible control the optical properties with magnetic fields.

In this presentation we will show a fundamental study of the properties of an emitter in two different situations: in the presence of a single magneto-optical nanoparticle and inside of a cavity formed by two magneto-optical nanoparticles. We analyze the dependence of the decay rate and the field patterns in the presence and absence of the magnetic field.

In the first case we show that the decay rate of an emitter is invariant in respect to the out-of-diagonal elements of the polarizability tensor, although the field patterns of the system can be modified.

In the second case we study the modification of the emission pattern considering the coupling between particles. Like in the previous situation, we also explore the modifications of the decay rate dependence as well as the field patterns.

MA 13.7 Tue 12:15 HSZ 04

Magneto-Photonic Intensity Effects in Hybrid Metal-Dielectric Structures — V.I. Belotelov[1,2,3], •M. Jäckl[4], L.E. Kreilkamp[4], A.N. Kalish[1,2,3], I.A. Akimov[4,5], D.A. Bykov[6], S. Kasture[7], V.J. Yallapragada[7], Achanta Venu Gopal[7], A.M. Grishin[8], S.I. Khartsev[8], M. Nur-E-Alam[9], M. Vasiliev[9], L.L. Doskolovich[6], D.R. Yakovlev[4,5], K. Alameh[9], A.K. Zvezdin[2,3], and M. Bayer[4] — [1]Lomonosov Moscow State University, Leninskie gori, 119991 Moscow, Russia — [2]Russian Quantum Center, 143025 Skolkovo, Moscow Region, Russia — [3]Prokhorov General Physics Institute, Russian Academy of Sciences, 119991 Moscow, Russia — [4]Experimental Physics 2, TU Dortmund University, 44221 Dortmund, Germany — [5]Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [6]Image Processing Systems Institute, Russian Academy of Sciences, 443001 Samara, Russia — [7]Tata Institute of Fundamental Research, 400005 Mumbai, India — [8]Royal Institute of Technology, Kungl Tekniska Hogskolan, 164 40 Stockhol-Kista, Sweden — [9]Electron Science Research Institute, Edith Cowan University, 6027 Joondalup, W.A., Australia

We present our study on a novel magneto-optical phenomenon observed in a hybrid metal-dielectric structure consisting of a one-dimensional gold grating on top of a magnetic waveguide layer. A magnetic field applied perpendicularly to the grating slits modifies the field distribution of the optical modes and thus changes the mode excitation conditions. In the optical far-field, this manifests in the alteration of the optical transmittance or reflectance.

Lunch Break (60 min.)

Topical Talk MA 13.8 Tue 13:30 HSZ 04

Magnetoplasmonics with plasmon nanoantennas — •Alexandre Dmitriev — Applied Physics, Chalmers University of Technology, 41296 Göteborg, Sweden

The combination of magnetism and plasmonics developed into a new burgeoning field, where the control of non-reciprocity in light's interaction with a magnetized media is targeted for various applications. I discuss the use of various ferromagnetic or hybrid noble metal-ferromagnetic plasmon nanoantennas to achieve broadband control of the magneto-optic response over the entire visible and near-infrared wavelength range. One example is the deployment of the magneto-plasmonic anisotropy to earn the broadband tunability of both the sign and amplitude of the Kerr rotation, crafting the manifold enhanced magneto-optical response of a chosen sign in spectral regions where the same ferromagnetic thin-film material shows the complete absence of naturally occurring magneto-optical Kerr effect. Another example is magnetoplasmonics-controlled circular dichroism.

MA 13.9 Tue 14:00 HSZ 04

Optical and magnetic properties of ferromagnetical nanostructures evolving from islands to holes — •Hui Fang — Institut fuer Experimentalphysik, Freie Universitaet Berlin Arnimallee 14 D-14195 Berlin (Germany)

The optical and magneto-optic properties of nanostructured ferromagnetic films will be presented. A series of Nickel and Cobalt thin-film periodic nanostructures evolving from islands to holes were produced by the method named self-assembly sphere lithography (SSL), varying the holes diameters while keeping the lattice constant fixed. We have observed the enhancement of Kerr rotation, which is related to the surface plasmon resonances and the size and the shape of the periodic nanostructures. Further we provide the experimental demonstration of plasmonic resonances in a percolation series of periodic nanostructures even in ferromagnets.

MA 13.10 Tue 14:15 HSZ 04

Spatially resolved magneto-optic surface plasmon resonance measurements in IrMn/Co/Au layers with parallel-stripe domains — •Nicolas Müglich, Sebastian Kübler, Kerstin Kämpf, Friedrich Herberg, 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

In the past it has been demonstrated that the sensitivity of surface plasmon resonance (SPR) based biosensors can be improved by a combined measurement of the SPR effect and the transverse magneto-optic Kerr effect. The magneto-optic surface plasmon resonance (MOSPR) of Au/IrMn/Co/Au exchange biased thin film systems, magnetically stripe patterned by He ion bombardment, has been measured spatially and angular resolved in transverse geometry. We show promising results which indicate that MOSPR based sensors may be designed without the usage of external magnetic fields in the future.

Topical Talk MA 13.11 Tue 14:30 HSZ 04

Ultrafast phenomena in magneto-plasmonic multilayer structures — •Vasily Temnov — Institut des Molécules et Matériaux du Mans, UMR CNRS 6283, Université du Maine, 72085 Le Mans cedex, France

The ultimate speed limits of magneto-plasmonic devices can be explored by monitoring the ultrafast dynamics in metal-ferromagnet multilayer structures excited by intense femtosecond laser pulses.

In this talk I will discuss the interaction mechanisms between transient plasmonic, electronic, acoustic and magnetic excitations observed in these structures at ultrafast time scales [1].

[1] V.V. Temnov, "Ultrafast acousto-magneto-plasmonics", Nature Photonics 6, 728 (2012)

POSTER

MA 13.12 Tue 15:01 HSZ 04

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 various optical characterization methods like Raman spectroscopy made use of the excitation of plasmons in metallic nanoparticles. Due to a local field enhancement provided by localized plasmons the signal strength as well as the spatial resolution can be significantly increased. This effect is often referred to as surface enhancement 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 gold and silver nanoparticles on top. At the position of the nanoparticles an increase of the BLS signal as well as a frequency shift of the spin waves is observed. Besides their plasmonic properties other influences of the nanoparticles on the magnetization dynamics have to be taken into account. In order to identify the different contributions to the observed signal changes, investigations using different materials, sizes and shapes of the structures have been performed.

MA 13.13 Tue 15:01 HSZ 04

Magnonic grating coupler effect in a ferromagnetic thin film with a periodic array of embedded nanodisks — •Stefan Maendl, Florian Heimbach, Haiming Yu, and Dirk Grundler — Physik Department E10, TU München, Garching, Germany

Magnonics is a growing research field where one aims at controlling spin waves on the nanoscale. Microwave-to-magnon transducers are in particular important for coupling magnonic devices to conventional microwave circuits. It was found recently that the reciprocal-lattice vector provided by a periodic lattice of non-resonant magnetic nanodisks adds to the wave vector of a Damon-Eshbach mode that a coplanar wave guide induces in an underlying ferromagnetic thin film [1]. In the present work, we aim at optimizing this so-called grating-coupler effect for different material combinations, lattice constants, symmetries of the lattice and/or sizes of the nanodisks. We report our recent results. The work is supported by the DFG via GR1640/5 in SPP 1538 and NIM.

[1] H. Yu et al., Nat. Commun. 4, 2702 (2013)

MA 13.14 Tue 15:01 HSZ 04

Plasmonic and magnonic waveguide excitations in $Ni_{81}Fe_{19}$-Au bilayer microstructures investigated by means of photoemission spectroscopy and Brillouin light scattering spectroscopy — •Philip Thielen[1,2], Markus Rollinger[1], Pascal Melchior[1], Thomas Meyer[1], Björn Obry[1], Burkard Hillebrands[1], and Martin Aeschlimann[1] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School of Excellence Materials Science in Mainz, Kaiserslautern, Germany

The interaction between magnons and plasmons has been scarcely investigated up to now. In our contribution, we present a preliminary study on the excitation of magnons and plasmons in microstructured $Ni_{81}Fe_{19}$-Au bilayers. Here, 8-15 μm wide $Ni_{81}Fe_{19}$ stripes act as spin-wave waveguides. The magnonic excitation is induced through the Oersted field of a microwave current in a Cu antenna situated on top of the waveguides. By means of Brillouin light scattering, the excitation of magnons in these waveguides is observed. Additionally, Au nanostructures on top of the $Ni_{81}Fe_{19}$ stripes serve as plasmonic waveguides and resonators. The optical excitation of propagating as well as localized surface plasmons in those structures is observed by employing photoemission electron microscopy. These first investigations show a way to examine magnonic as well as plasmonic excitations in the same structure, providing a starting point to study their interaction.

MA 13.15 Tue 15:01 HSZ 04

Magnetoplasmonics in Co and Ni nanoferromagnets — •Irina Zubritskaya[1], Kristof Lodewijks[2], Randy Dumas[3], Addis Mekkonen[4], Johan Åkerman[5], and Alexandre Dmitriev[6] — [1]Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden — [2]Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden — [3]Department of Physics, University of Gothenburg, Gothenburg, Sweden — [4]Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden — [5]Department of Physics, University of Gothenburg, Gothenburg, Sweden — [6]Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden

In our study, we compare magnetoplasmonic response in pure ferromagnetic nanostructures made of Co and Ni with magneto-optical response in respective continuous films of the same thickness. We show that localized surface plasmon resonances determine the magneto-optical response. Spectroscopic Kerr rotation values for all types of nanostructures and continuous films are obtained using longitudinal magneto-optical Kerr effect (L-moke) in P- and S- configurations of light polarization with respect to the magnetic field covering the region of wavelengths from 450 to 1100 nm. Both magnitude and sign of Kerr rotation angle depend on which plasmonic mode is excited and how the electric and the magnetic fields are oriented with respect to each other. We also demonstrate how the magnetic coupling between the particles in a dimer is affected by the gap size.

MA 14: Bio- and Molecular Magnetism

Time: Tuesday 9:30–12:15 Location: HSZ 401

MA 14.1 Tue 9:30 HSZ 401

Magnetic Coupling of $Gd_3N@C_{80}$ Endohedral Fullerenes to a Substrate — Christian F. Hermanns[1], •Matthias Bernien[1], Alex Krüger[1], Christian Schmidt[1], Sören T. Wasserroth[1], Gelavizh Ahmadi[1], Benjamin W. Heinrich[1], Martin Schneider[2], Piet W. Brouwer[2], Katharina J. Franke[1], Eugen Weschke[3], and Wolfgang Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Straße 15, 12489 Berlin

Using magnetic endohedral fullerenes for molecular spintronics requires control over their encapsulated magnetic moments. We show by field-dependent x-ray magnetic circular dichroism measurements of $Gd_3N@C_{80}$ endohedral fullerenes adsorbed on a Cu surface that the magnetic moments of the encapsulated Gd atoms lie in a $4f^7$ ground state and couple ferromagnetically to each other. When the molecules are in contact with a ferromagnetic Ni substrate, we detect two different Gd species. The more abundant one couples antiferromagnetically to the Ni magnetization, whereas the other one exhibits a stronger and ferromagnetic coupling to the substrate. Both of these couplings to the substrate can be explained by an indirect exchange mechanism mediated by the carbon cage. The origin of the distinctly different behavior may be attributed to different orientations and thus electronic coupling of the carbon cage to the substrate.

Financial support by the DFG (Sfb 658) is gratefully acknowledged.

MA 14.2 Tue 9:45 HSZ 401

Interaction of FeP and FePc with magnetic surfaces: adsorption structures, magnetic coupling and spin manipulation — •Barbara Brena[1], Heike Herper[1], Sumanta Bhandary[1], David Klar[2], Heiko Wende[2], Olle Eriksson[1], and Biplab Sanyal[1] — [1]Department of Physics and Astronomy, Uppsala University, Box 516, 751 20 Uppsala, Sweden — [2]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Lotharstraße 1, D-47048 Duisburg, Germany

The interaction of organic molecules like porphyrins and phthalocyanines containing divalent 3d transition metals with magnetic substrates provides a possible mechanism of magnetic switching. We have studied the chemisorption of Fe porphyrins (FeP) and of Fe phthalocyanines (FePc) on Co(001) by means of Density Functional Theory with the GGA+U method, including van der Waals dispersion forces. Two different adsorption mechanisms were identified for the two molecules. In both cases a ferromagnetic coupling with the surface was observed, but while the FePc's maintain a magnetic moment of about 2 μ_B, close to the gas phase value, the magnetic moment of the FeP's is increased up to about 4 μ_B. The change to high spin (S=2) in FeP is driven by the stretching of the Fe-N molecular bonds to more than 2.04 Å, due to the strong chemical interaction with the substrate. The same results have been obtained for FeP chemisorbed on Ni(001), Ni(110) and Ni(111). Fe L edge and N K edge experimental absorption spectroscopy results confirm our theoretical findings related to the magnetic coupling and to the adsorption structure of the molecules.

MA 14.3 Tue 10:00 HSZ 401

FePc on Co(001): Influence of surface oxidation on structure, magnetism, and exchange coupling — •Heike C. Herper[1], Barbara Brena[1], Sumanta Bhandary[1], David Klar[2], Heiko Wende[2], Biplab Sanyal[1], and Olle Eriksson[1] — [1]Department of Physics and Astronomy, Uppsala University, Sweden — [2]Fakultät für Physik und CeNIDE, Universität Duisburg-Essen, Germany

We present a density functional theory study combined with x-ray absorption spectroscopy measurements of the electronic and magnetic properties of Fe phthalocyanine (FePc) molecules on fcc Co(001) and c(2×2)O/Co(001). On the bare Co substrate one adsorption site is clearly preferred whereas the oxygen adlayer screens the molecule-substrate interaction and the energy differences between different adsorptions sites become smaller. Moreover the coupling between the Fe center and the Co surface switches from ferromagnetic to antiferromagnetic and the coupling strength is reduced due to the O layer. [1] Notably the coupling mechanisms also differ. On the Co(001) substrate a mixture of direct coupling between Fe and Co and an indirect coupling via the benzene rings is obtained from the DFT calculations whereas on the oxidized surface, an 180° coupling between Fe and Co via O dominates. Despite the changes in adsorption site and coupling, the spin state of the molecule is $S = 1$ on both substrates.

[1] D. Klar et al., submitted to PRB

MA 14.4 Tue 10:15 HSZ 401

Magnetization studies of Cu-(bis) oxamato complexes with ferrocenium ligand — •Azar Aliabadi[1], Andreas Petr[1], Mohammad A. Abdulmalic[2], Tobias Rüffer[2], Vladislav Kataev[1], and Bernd Büchner[1] — [1]IFW Dresden, Dresden, Germany — [2]Institute of Chemistry, Chemnitz University of Technology, Chemnitz, Germany

Magnetic properties of Cu-(bis) oxamato complexes with ferrocenium ligand ($[^nBu_4N]_2[Cu(1,1'\text{-fcba})]$ (**1**) and $[Cu3(1,1'\text{-fcba})(pmdta)_2](NO_3)_3$ (**2**)) were studied by static magnetic susceptibility and ESR spectroscopy.

For **1** a weak antiferromagnetic coupling between the Cu(II) and Fe(III) ions has been obtained. For **2** an antiferromagnetic coupling of -64 cm^{-1} ions and a weak ferromagnetic coupling between the central Cu(II) ion and the Fe(III) ion have been found.

The ESR spectrum of 1 at $f = 9.56$ GHz and at 4K is a superposition of a signal from Cu(II) and of additional signals which can be attributed to a ferrocenium cation. The shape and the position of the peaks clearly demonstrate two different phases of ferrocenium.

The ESR spectrum of 2 at 4K consists of a single line at a field of 0.32 T which can be assigned to a joint resonance response of three Cu(II) ions and one Fe(III) ion. The calculated isotropic g-factor 2.11 is typical to a g-factor of Cu(II) and also indicates a strong distortion of the axial symmetry in ferrocenium cation.

We discuss possible correlations between the structure of the complexes and their magnetic properties.

MA 14.5 Tue 10:30 HSZ 401

High-field ESR and magnetization studies of a binuclear Ni(II) complex — •Azar Aliabadi[1], Karoline Rühlig[2], Tobias Rüffer[2], Vladislav Kataev[1], Heinrich Lang[2], and Bernd Büchner[1] — [1]IFW Dresden, Dresden, Germany — [2]Institute of Chemistry, Chemnitz University of Technology, Chemnitz, Germany

We have investigated magnetic properties of a binuclear Ni(II) complex by means of the static magnetization and high-field high-frequency tunable electron spin resonance (HF-ESR). In this compound, two Ni(II) ions each having a spin S=1 are coupled antiferromagnetically which leads to a $S_{tot} = 0$ ground state.

Frequency-dependent HF-ESR spectra yield a g-factor of 2.22. Analysis of the frequency dependence of the ESR signals reveals a positive anisotropy ($D > 0$) corresponding to an easy plane situation and transverse anisotropy for each Ni ion. The calculation of the magnetic field dependence of the spin state energies from the relevant spin Hamiltonian with the experimentally determined set of parameters predicts a change of the ground state from a nonmagnetic singlet state to magnetic ones with increasing the magnetic field due to the level crossings. Such tuning of the ground state by application of a strong magnetic field has been confirmed in the HF-ESR experiments.

15 min. break

MA 14.6 Tue 11:00 HSZ 401

Magnetization studies of Cu-(bis) oxamato complexes with ferrocenium ligand — Azar Aliabadi[1], •Andreas Petr[1], Mohammad A. Abdulmalic[2], Tobias Rüffer[2], Vladislav Kataev[1], and Bernd Büchner[1] — [1]IFW Dresden, Dresden, Germany — [2]Institute of Chemistry, Chemnitz University of Technology, Chemnitz, Germany

Magnetic properties of Cu-(bis) oxamato complexes with ferrocenium ligand ($[^nBu_4N]_2[Cu(1,1'\text{-fcba})]$ (**1**) and $[Cu3(1,1'\text{-fcba})(pmdta)_2](NO_3)_3$ (**2**)) were studied by static magnetic susceptibility and ESR spectroscopy.

For **1** a weak antiferromagnetic coupling between the Cu(II) and Fe(III) ions has been obtained. For **2** an antiferromagnetic coupling of -64 cm^{-1} ions and a weak ferromagnetic coupling between the central Cu(II) ion and the Fe(III) ion have been found.

The ESR spectrum of 1 at $f = 9.56$ GHz and at 4K is a superposition of a signal from Cu(II) and of additional signals which can be attributed to a ferrocenium cation. The shape and the position of the peaks clearly demonstrate two different phases of ferrocenium.

The ESR spectrum of 2 at 4K consists of a single line at a field of 0.32 T which can be assigned to a joint resonance response of three Cu(II) ions and one Fe(III) ion. The calculated isotropic g-factor 2.11 is typical to a g-factor of Cu(II) and also indicates a strong distortion of the axial symmetry in ferrocenium cation.

We discuss possible correlations between the structure of the complexes and their magnetic properties.

MA 14.7 Tue 11:15 HSZ 401

Effects of the DM-interaction on thermodynamic properties of a small spin system — •Christian Heesing and Jürgen Schnack — Universität Bielefeld, Bielefeld, Germany

The magnetism of many magnetic molecules is dominated by isotropic Heisenberg exchange interactions. For 3d elements anisotropic contributions are usually small. Nevertheless, they can have drastic consequences at low temperatures as for instance on bistability and quantum tunnelling in the case of easy-axis anisotropies.
In this contribution we investigate the effect of the Dzyaloshinskii-Moriya (DM) interaction [1,2] on thermodynamic magnetic observables such as the low-temperature magnetization. The full Hamiltonian contains Heisenberg exchange, Zeeman term, and Dzyaloshinskii-Moriya interaction. We investigate as an archetypical model system the cuboctahedron. Thermodynamic observables are systematically compared for various ratios of DM and Heisenberg interaction strength.

[1] T. Moriya, Phys. Rev., 1960, 120, 90-98
[2] I. Dzyaloshinskii, J. Phys. Chem. Solids, 1958, 4, 241-255

MA 14.8 Tue 11:30 HSZ 401

Magnetization curves of deposited spin clusters — •Henning-Timm Langwald and Jürgen Schnack — Bielefeld University, Bielefeld, Germany

For future technological applications deposited magnetic clusters offer a significant potential. To utilize this potential requires to characterize these clusters while they are in contact with a substrate. Experimentally, techniques such as spin-flip inelastic tunneling spectroscopy are very useful in this context. These techniques can be used to determine e.g. exchange parameters for effective spin models of the magnetic clusters. One possible approach here is to detect ground state level crossings in an applied magnetic field which serve as fingerprint for the aforementioned spin models.

In this talk we address antiferromagnetic spin chains on a metallic substrate theoretically. The coupling to a conduction electron band of the substrate can lead to a screening of a part of the spin chain and thus influence the crossing fields. By means of the Numerical Renormalization Group method (NRG) we investigate how the exchange coupling to the substrate's conduction electrons influences the magnetic properties and show the differences between partial and full screening of the spin closest to the substrate.

MA 14.9 Tue 11:45 HSZ 401

Anisotropic superexchange in $Mn_6^{III}Os^{III}$ single-molecule magnets — •Jürgen Schnack — Bielefeld University, P.O. box 100131, D-33501 Bielefeld

Transition metal substitution from 3d to 5d elements may result in strongly anisotropic exchange interactions with a pronounced influence on the anisotropic magnetic response and the behavior as a single-molecule magnet. Here we present recent theoretical investigations of a new compound involving osmium (III).

V. Höke, A. Stammler, H. Bögge, J. Schnack, T. Glaser, Inorg. Chem., in press.

MA 14.10 Tue 12:00 HSZ 401

A Spin-Crossover Complex on Surfaces — •Matthias Bernien[1], Thiruvancheril G. Gopakumar[2], Holger Naggert[3], Francesca Matino[2], Christian F. Hermanns[1], Alexander Bannwarth[3], Svenja Mühlenberend[2], Alex Krüger[1], Dennis Krüger[1], Fabian Nickel[1], Waldemar Walter[1], Richard Berndt[2], Wolfgang Kuch[1], and Felix Tuczek[3] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel — [3]Institut für Anorganische Chemie, Christian-Albrechts-Universität zu Kiel, 24098 Kiel

The manipulation of the spin-state of molecules on surfaces is a promising route towards tailor-made molecular building blocks for spintronic devices. Spin crossover (SCO) molecules are appealing since their spin state can be switched by external stimuli, such as temperature and light. Recently, a lot of research has been devoted to vacuum-deposition of SCO molecules using neutral complexes.

We have studied submono-, mono-, and multilayers of the Fe(II) SCO complex $[Fe(bpz)_2(phen)]$ (bpz=dihydrobis(pyrazolyl)borate, phen=1,10-phenanthroline) by near-edge x-ray absorption fine structure and scanning tunneling microscopy. We find that $[Fe(bpz)_2(phen)]$ in direct contact with a Au(111) surface dissociates into the four-coordinate complexes, $[Fe(bpz)_2]$, and phen molecules. Molecules in the second layer, on the other hand, are intact and show a SCO transition. — Financial support by the DFG (Sfb 658 and 677) is gratefully acknowledged.

MA 15: Spin structures and Magnetic Phase Transitions

Time: Tuesday 9:30–13:15 Location: HSZ 403

MA 15.1 Tue 9:30 HSZ 403

The prototype chiral ferromagnet FeGe: phase diagram, Skyrmions and ^{57}Fe magnetic resonance — •Michael Baenitz[1], Panchanan Khuntia[1], Markus Schmidt[1], Ulrich Roessler[2], and Heribert Wilhelm[3] — [1]MPI for the Chemical Physics of Solids, 01187Dresden, Germany — [2]Leibniz Institute for SolidState and Materials Research, 01171 Dresden, Germany — [3]Diamond Light Source Ltd, Didcot, Oxfordshire,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 phases). From an NMR point FeGe is a prototype system to study chiral excitations directly "on-site" via the ^{57}Fe nucleus because of its S=1/2 nuclear spin. Here, in contrast to MnSi or MnGe (where ^{55}Mn has S=5/2), the absence of quadrupolar interactions, which usually creates broad NMR lines, makes detailed investigations of the anisotropic Zeeman interaction in internal/external fields possible. ^{57}Fe NMR allows 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 critical dynamics in the vicinity of these boundaries are obtained from the spin-lattice and spin-spin relaxation rate.

MA 15.2 Tue 9:45 HSZ 403

Fluctuation-induced First Order Quantum Phase Transition of U(1) Quantum Spin Liquid in Pyrochlore Quantum Antiferromagnet — •Imam Makhfudz — Johns Hopkins University, Baltimore, USA

We predict using quantum free energy calculation that the quantum phase transition between U(1) quantum spin liquid (QSL) and antiferromagnet (AFM) phases in pyrochlore quantum antiferromagnet (QAFM) is a first order rather than second order. This change in order from second to first order is induced by gauge fluctuations, which are explicitly taken into account at gauge theory level in our effective low energy theory. We therefore have discovered a fluctuation-induced first order quantum phase transition in pyrochlore QAFM. We explicitly derive the quantum free energy description of this QSL to AFM phase transition and predict that it is a weakly first order phase transition. We also briefly discuss the experimental relevance of this result.

MA 15.3 Tue 10:00 HSZ 403

Investigation of the Spin-Peierls Transition in $TiPO_4$ — •Patrick Reuvekamp[1], Reinhard K. Kremer[1], Joseph M. Law[2], and Robert Glaum[3] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]Helmholtz-Zentrum Dresden-

Rossendorf, Dresden, Germany — [3]Rheinische Friedrich-Wilhelms-Universität, Institut für Anorganische Chemie, Bonn, Germany

At room temperature, $TiPO_4$ crystallizes in the orthorhombic $CrVO_4$ structure type characterized by one-dimensional equidistant Ti atoms running along the ***c***-axis. From high temperature magnetic susceptibility measurements, the afm intrachain spin exchange between the Ti^{3+} ($3d^1$, $S = 1/2$) cations was observed to be 965 K which is remarkably large for a spin-Peierls (SP) compound.[1] Below room temperature, a two stage SP transition occurs comprising two sequential magnetostructural phase transitions at $T_{c2} \sim 110$ K and $T_{c1} \sim 74$ K into a non-magnetic singlet groundstate. NMR measurements indicated the intermediate phase to be incommensurate.[1] Utilizing low-temperature single-crystal x-ray diffraction and thermal expansion measurements, we investigated in detail the temperature and magnetic field dependence of these two transitions and observed a dimerization of the Ti chains below T_{c2}. We observed that only the T_{c1} transition is dependent on the magnetic field. At 9 T, T_{c2} decreases by ~ -100 mK. The magnetic field dependence of $\Delta T_{c1}/T_{c1} \propto H^2$, consistent with standard SP theory.[1]J. M. Law *et al.*, Phys. Rev. B **83**, 180414 (2011). [2]M. Bykov *et al.*, Phys. Rev. B **88**, 184420 (2013).

MA 15.4 Tue 10:15 HSZ 403

Magnetic transitions in Mn/Ag(111) — •Jingfan Ye, Franziska Lambrecht, Timofey Balashov, and Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

An antiferromagnetic manganese monolayer on Ag(111) exhibits a 120°-Néel structure due to geometric frustration [1]. Using a spin-polarized scanning tunneling microscope, we investigated the ground state of Mn islands on Ag(111) of sizes between 10 and 10000 nm^2 at 4K. We found out that the magnetic contrast disappears below a certain island size. In an intermediate region, it was also possible to observe switching between different configurations of the Néel state, at a rate scaling linearly with an externally applied magnetic field. We attribute the observed effects to a quantum phase transition, in which the anisotropy barrier between the classical ground states is lowered with decreasing island size and increasing magnetic field [2].

[1] C.-L. Gao et al. *Phys. Rev. Lett.* **101**, 267205 (2008)

[2] P. Legett et al. *Rev. Mod. Phys.* **59**, 1-85 (1987)

MA 15.5 Tue 10:30 HSZ 403

Spin structures and electron lattice coupling in the double perovskite Sr_2FeOsO_6 — Avijit Kumar Paul[1], •Peter Adler[1], Manfred Reehuis[2], Vadim Ksenofontov[3], Binghai Yan[1], Martin Jansen[1], and Claudia Felser[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany — [2]Helmholtz-Zentrum für Materialien und Energie, Berlin, Germany — [3]Johannes Gutenberg-Universität, Mainz, Germany

Double perovskites with an ordered arrangement of transition metal 3*d* and 4*d* or 5*d* sites show remarkable magnetic properties like half-metallic ferromagnetism below 400 K in Sr_2FeMoO_6 or ferrimagnetism with a high T_C of 725 K in the insulator Sr_2CrOsO_6. We have studied the magnetic and electronic properties of insulating Sr_2FeOsO_6 by neutron powder diffraction, ^{57}Fe Mössbauer spectroscopy and spin-polarized density functional theory calculations. Sr_2FeOsO_6 shows two magnetic phase transitions below 140 and 67 K, respectively. Similar as in related systems the spin structures reveal ferrimagnetic ordering of Fe and Os moments within the planes of the tetragonal crystal structure. Along *c*, however, two different spin alignment patterns are adopted which lead to overall antiferromagnetic behavior. Our experimental and theoretical results suggest a frustrated magnetic behavior, where the frustration is partially released by a Peierls-like lattice modulation and a switch of the spin structure below 67 K. Thus, Sr_2FeOsO_6 features an intimate interplay of lattice, spin and orbital degrees of freedom.

MA 15.6 Tue 10:45 HSZ 403

Absorption and photoluminescence spectroscopy on copper metaborate CuB_2O_4 — •Dennis Kudlacik[1], J. Debus[1], R. V. Pisarev[2], D. Dunker[1], D. R. Yakovlev[1,2], and M. Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

CuB_2O_4 contains two nonequivalent Cu^{2+} sublattices, each with different magnetic ordering. The magnetic structure is dominated by the antiferromagnetic order of the 4b sublattice. Interactions may transfer it to the 8d sublattice where it shall coexist with a paramagnetic component. Three different magnetic phase transitions can be observed below 21 K.[1] Accordingly, it is an ideal candidate to probe magnetic interactions between both sublattices as a function of temperature and, for example, optical excitation. We have studied linear-polarized absorption spectra, magneto-photoluminescence (PL) and photoluminescence excitation (PLE) of CuB_2O_4. The absorption and PL spectra show a rich fine structure containing up to six zero phonon lines. We compare the intensities of the zero phonon lines and magnon related emission lines for the different states of magnetic ordering. Also, the PLE spectroscopy reveals the coupling between the 8d and 4b sublattices. On the whole, the applied optical techniques grant access to crystallographic and magnetic properties of CuB_2O_4.

[1] R.V. Pisarev et al., Phys. Rev. Lett. 93, 037204 (2004).

MA 15.7 Tue 11:00 HSZ 403

Spin relaxation in frustrated 2D antiferromagnets α-ACr_2O_4 ($A =$ Ca, Sr) — •Martina Schädler, Mamoun Hemmida, Hans-Albrecht Krug von Nidda, and Alois Loidl — Experimental Physics V, EKM, University of Augsburg, 86135 Augsburg, Germany

Electron Spin Resonance (ESR) measurements were performed at X-band (9.4 GHz) and Q-band (34 GHz) frequency on polycrystalline samples of α-$CaCr_2O_4$ and α-$SrCr_2O_4$. In both compounds the magnetic Cr^{3+} ions form slightly distorted triangular layers, representing a frustrated 2D Heisenberg antiferromagnet with alternating exchange. The spin-spin relaxation behavior derived from the temperature dependence of the ESR-linewidth (ΔH) exhibits two different regimes. At temperatures $T > 2T_N$ a BKT-like scenario [1,2] suggests the existence of Z_2 vortices as observed in the prototype triangular lattice Heisenberg antiferromagnet $CuCrO_2$ [3]. For $T_N < T < 2T_N$ fluctuations due to the onset of 3D antiferromagnetic order seem to dominate.

We thank for sample preparation: S. Toth and B. Lake, Helmholtz Zentrum Berlin, Germany (α-$CaCr_2O_4$), S. E. Dutton and R. J. Cava, Princeton University, USA (α-$SrCr_2O_4$).

References: [1] V. L. Berezinskii, J. Exp. Theor. Phys. **32**, 493 (1971). [2] J. M. Kosterlitz and D. J. Thouless, J. Phys. C **6**, 1181 (1973). [3] M. Hemmida, H.-A. Krug von Nidda, and A. Loidl, J. Phys. Soc. Jpn. **80**, 053707 (2011).

15 min. break

MA 15.8 Tue 11:30 HSZ 403

Restoration of 2D Ising criticality in dipolar-frustrated ferromagnetic films — •Danilo Andrea Zanin[1], Niculin Saratz[1], Boris Sangiorgio[1], Thomas C.T. Michaels[2], Alessandro Vindigni[1], Urs Ramsperger[1], and Danilo Pescia[1] — [1]ETH Zurich, Switzerland — [2]University of Cambridge, United Kingdom

For about three decades the quest for novel paradigms for magnetostorage and spintronics has driven the development and investigation of magnetic nanostructured materials. For instance, the study of films magnetized in plane led to the observation of the two-dimensional Ising critical behavior. In films with easy axis directed out of plane the magnetization spontaneously splits into domains because of the competition between short-range exchange coupling and long-range dipolar interaction. A shrinking of the magnetic domains of in these films with increasing temperature was already observed, e.g., in Fe/Cu(001) samples by means of Scanning-Electron-Microscopy with Polarization Analysis (SEMPA). This phenomenon drives the occurrence of reentrant transitions of magnetic-domain patterns. However, approaching the Curie temperature, magnetic domains become mobile within the timescale of the experiment, which consequently blurs the SEMPA images. In order to extend the phase diagram to higher temperatures, we performed Magneto-Optic Kerr Effect (MOKE) experiments. Even though our MOKE setup does not allow a direct visualization of micrometric magnetic domains, by means of statistical analysis of the large data set, we identify clearly the transition between uniform to domain phase as a function of temperatures and applied magnetic field.

MA 15.9 Tue 11:45 HSZ 403

Quantifying entanglement with scattering experiments — •Oliver Marty[1], Michael Epping[2], Hermann Kampermann[2], Dagmar Bruss[2], Martin Plenio[1], and Marcus Cramer[1] — [1]Institut für Theoretische Physik, Universität Ulm — [2]Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf

We show how the entanglement contained in states of spins arranged on a lattice may be quantified with observables arising in scattering experiments. We focus on the partial differential cross-section obtained in neutron scattering from magnetic materials but our results are sufficiently general such that they may also be applied to, e.g., optical Bragg scattering from ultracold atoms in optical lattices or from ion chains. We discuss resonating valence bond states and ground and thermal states of experimentally relevant models–such as Heisenberg, Majumdar-Ghosh, and XY model–in different geometries and with different spin numbers. As a by-product, we find that for the one-dimensional XY model in a transverse field such measurements reveal factorization and the quantum phase transition at zero temperature.

[1] O. Marty et al., arXiv:1310.0929

MA 15.10 Tue 12:00 HSZ 403

Chiral spin liquid in a two-dimensional two-component helical magnet — •Olga Dimitrova — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln, Germany

A low-temperature method is developed, suited for a two-dimensional two-component classical helical magnet. Four phases on the phase diagram as functions of the temperature and the helicity parameter of the Hamiltonian are found. Among the three ordered phases two show magnetic order: the usual algebraic correlations of the magnetization and the algebraic correlations of the magnetization in the frame rotating according with the helical order. A chiral spin liquid phase emerges directly from the paramagnetic phase and has a scalar parity-breaking pitch of the magnetization as the order parameter. The chiral phase transition is found to be of a continuous second order type with a modified by the long-range interaction Ising universality class. All the critical exponents are calculated in the second and the third order of an ϵ-expansion. A new scaling relationship replacing the Josephson's one is found.

MA 15.11 Tue 12:15 HSZ 403

Studying finite-temperature magnetism using relativistic disordered local moment theory — •Andras Deak[1], Eszter Simon[1], Manuel dos Santos Dias[2], Laszlo Szunyogh[1], and Julie B. Staunton[3] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary — [2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, Jülich, Germany — [3]Department of Physics, University of Warwick, United Kingdom

Numerical investigations of magnetic phenomena at finite temperatures are mostly based on Heisenberg-type spin models treated with methods of statistical physics (Monte Carlo or Langevin dynamics simulations). Although the parameters of such models can be obtained from first principles calculations, neglecting higher-order spin interactions and longitudinal spin fluctuations may impose drastic restrictions on the applicability of such approaches.

In this talk we present a "first principles only" approach to studying finite-temperature magnetism. The method is based on the Disordered Local Moment (DLM) picture that can be merged efficiently with the Local Spin-Density Functional Approximation (LSDA) of Density Functional Theory (DFT). In particular, solving the Kohn–Sham–Dirac equation allows for investigating relativistic effects. We demonstrate the new computational scheme for the temperature dependence of the magnetocrystalline anisotropy energy of chemically ordered and disordered bulk FePt alloys, and the metamagnetic phase transition in bulk FeRh from antiferromagnetic to ferromagnetic phase.

MA 15.12 Tue 12:30 HSZ 403

Evidence of spin-charge correlation and its interplay with superconductivity in 1/8-doped $La_{2-x}Sr_xCuO_4$ and $La_{2-x}Ba_xCuO_4$ – a ^{139}La spin-lattice relaxation study — •Seung-Ho Baek[1], Markus Hücker[2], Andreas Erb[3], Genda Gu[2], Bernd Büchner[1], and Hans-Joachim Grafe[1] — [1]IFW-Dresden, Institute for Solid State Research, PF 270116, 01171 Dresden, Germany — [2]Brookhaven National Laboratory, Upton, New York 11973, USA — [3]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meißner-Straße 8, D-85748 Garching, Germany

We discuss the ^{139}La nuclear magnetic resonance (NMR) spin-lattice relaxation rate T_1^{-1} of $La_{2-x}Sr_xCuO_4$ (LSCO:x, $0.07 \leq x \leq 0.15$) as well as 1/8-doped $La_{2-x}Ba_xCuO_4$ (LBCO:1/8) single crystals. A doping of 1/8-holes induces an unusual spin freezing behavior which, though much weaker, resembles stripe-ordered LBCO:1/8. Together with previous ^{139}La T_1^{-1} data of $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$ (LESCO), we provide compelling evidence that charge order is closely connected with spin freezing occurring in $\sim 1/8$-doped La cuprates. The unconventional external field dependence of the spin freezing in LSCO:1/8, which is absent in non-superconducting LESCO:0.13 and LBCO:1/8, suggests a competing relationship between charge order and superconductivity.

MA 15.13 Tue 12:45 HSZ 403

RKKY Interactions in Quasiperiodic Systems — •Stefanie Thiem and John Chalker — Theoretical Physics, Oxford University, 1 Keble Road, Oxford OX1 3NP, UK

We study the structure of the magnetic ground state and the low-temperature behaviour of the magnetic moments in quasiperiodic tilings due to the RKKY mechanism. We compute the exchange interactions between the magnetic impurities by a continued fraction expansion of the Green's function of the conduction electrons. Based on these results we apply Monte Carlo simulations to study the alignment of the Ising spins in these tilings.

MA 15.14 Tue 13:00 HSZ 403

Long range magnetic ordering and spin dynamics in the itinerant magnets $V_{1-x}Cr_xPtGe$ (x=0...0.2) — Sarah Ackerbauer[1], •Helge Rosner[1], Andreas Leithe-Jasper[1], Pabitra Biswas[2], Rustem Khasanov[2], and Yuri Grin[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Straße 40, 01187 Dresden — [2]Paul Scherrer Institut, CH-5232 Villigen, Switzerland

Weak itinerant magnets are in the focus of present-day physical studies due to a range of unusual properties, including strong magneto-elastic effects and superconductivity. Despite the large interest in these systems, their theoretical description is far from being fully established. Especially, the interplay or competition of localized moments and band magnetism is only poorly understood. This renders systems composed of usually nonmagnetic elements very suitable for a systematic study of this interplay. Here, we present a joint experimental and theoretical study of the electronic and magnetic properties of the novel compounds $V_{1-x}Cr_xPtGe$ ($x = 0...0.2$). For $x = 0$ the system exhibits strong spin fluctuations, but does not show long range magnetic order down to 2K. Density functional band structure calculations predict the stabilization of a magnetic ground state by moderate electron doping. We realized this experimentally by Cr substitution on the V site and indicate the development of bulk long range magnetic order with T_N up to 15 K by thermodynamic measurements and μ_{SR} measurements.

MA 16: Multiferroics I (jointly with DF, DS, KR, TT)

Time: Tuesday 9:30–12:45 Location: BEY 118

MA 16.1 Tue 9:30 BEY 118

***Ab initio* study of electronic transport in the Co/PZT-based tunnel junctions** — •Vladislav Borisov[1], Sergey Ostanin[1], Igor Maznichenko[2], Arthur Ernst[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

Magnetoelectric coupling at the multiferroic interfaces FM/FE (FM=Co,Fe, FE=$PbTiO_3$,PZT) was studied from first principles. The magnetic interfacial effect, which is controlled by the FE polarization, originates from the charge transfer and *d*-orbital redistribution of Co/Fe and Ti mediated by the *p*-states of interfacial oxygens. In PZT, the presence of Zr dopants may locally enhance the effect. We analysed also the spin polarization of tunneling electrons in Co/PTO/Co and Fe/PTO/Co junctions, in which the calculated four-state conductance can account for the ferroelectrically switchable TMR signal observed recently in LSMO/PZT/Co [1].

[1] D. Pantel *et al.*, *NATURE MATERIALS* **11**, 289 (2012).

MA 16.2 Tue 9:45 BEY 118

Tunneling transport and memristive effects in PbTiO3- based multiferroic tunnel junctions — •Andy Quindeau, Marin Alexe, and Dietrich Hesse — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

A gradually tunable resistance effect based on the tunnel electroresistance (TER) of multiferroic tunnel junctions is investigated. The ferroelectric tunnel barrier comprises, a PbTiO3 layer of a few nm thickness, is embedded between two different ferromagnetic layers, viz. La0.7Sr0.3MnO3 and cobalt. In this capacitor geometry an electric bias, applied perpendicularly to the films, results in a direct tunneling current flowing between the two electrodes. The tunnel resistance is dependent on the polarization of the ferroelectric, which is switchable via relatively high voltage pulses. Due to the variation of the pulse parameters a variety of non-volatile resistance states can easily be achieved. These gradually tunable resistance states, characteristic for a memristor device, can be explained by a ferroelectric domain distribution inside the ferroelectric film: Domains with different polarities can coexist inside one capacitor after partial polarization switching and act as parallel connected tunnel barriers with different tunnel resistances. Temperature dependent measurements show the influence of different electron transport mechanisms, which will be discussed. The impact of the memristive states on the tunnel magnetoresistance (TMR) can be shown.

MA 16.3 Tue 10:00 BEY 118

Lattice and polarizability mediated spin activity in EuTiO3 — •Annette Bussmann-Holder[1], Kevin Caslin[1,2], Patrick Reuvenkamp[1], Zurab Guguchia[3], Hugo Keller[3], Reinhard Kremer[1], and Jürgen Köhler[1] — [1]Max Planck Institute for Solid State Research, Heisenbergstr.1, D-70569 Stuttgart, Germany — [2]Brock University, 500 Glenridge Ave., St. Catharines L2S-3A1, Ontario, Canada — [3]Physik-Institut der Universität Zürich, Winterthurerstr. 190, CH-8057 Zürich, Switzerland

EuTiO3 is shown to exhibit novel strong spin-charge-lattice coupling deep in the paramagnetic phase. Its existence is evidenced by an, until now, unknown response of the paramagnetic susceptibility at temperatures exceeding the structural phase transition temperature TS=282K. The extra features in the susceptibility follow the rotational soft zone boundary mode temperature dependence above and below TS. In addition, novel magnetostriction experiments and dielectric constant measurements have been performed which both reveal giant anomalies related to the antiferromagnetic phase transition at TN=5.7K and the structural phase transition at TS. The theoretical modeling consistently reproduces these anomalies and provides evidence that EuTiO3 has considerable analogies to SrTiO3 but also substantial differences stemming from the Eu 4f spins which are lattice activated at high temperatures far above TN.

MA 16.4 Tue 10:15 BEY 118

Magnetoelectric coupling in a composite multiferroic structure revealed by Ferromagnetic Resonance — •Alexander Sukhov[1], Paul P. Horley[2], Chenglong Jia[3], and Jamal Berakdar[1] — [1]Martin-Luther-Universität Halle-Wittenberg, Halle/Saale, GERMANY — [2]Centro de Investigacion Materiales Avazados, S.C. (CIMAV), Chihuahua/Monterrey, MEXICO — [3]Lanzhou University, Lanzhou, CHINA

We theoretically study [1] a thin multiferroic junction related to a barium titanate (tetragonal or rhombohedral phase) layer in contact with an iron layer. Depending on the type of the magnetoelectric coupling at the interface - either due to screening charge or due to an epitaxial strain resulting in a strong magnetoelastic coupling - we present a detailed analysis of the response of the multiferroic structure to magnetic radio-frequency fields by means of ferromagnetic resonance as a function of the applied electric field.

[1] A. Sukhov, P.P. Horley, C.-L. Jia, J. Berakdar, J. Appl. Phys. **113**, 013908 (2013).

MA 16.5 Tue 10:30 BEY 118

Magnetoelectric monopoles in bulk periodic solids — •Michael Fechner[1], Eric Bousquet[1], Alexander Balatsky[2], Nicoal A. Spaldin[1], and Lars Nordström[3] — [1]ETH Zürich, Department for Materials Theory, Zürich, Switzerland — [2]NORDITA, KTH Royal Institute of Technology and Stockholm University, Stockholm, Sweden — [3]Department of Physics and Astronomy, Uppsala University, Sweden

The magnetoelectric (ME) response is described by a second rank tensor that can be decomposed into irreducible isotropic diagonal, antisymmetric and trace-free part. Here we show that the former component can be identified with a ferroic ordering of magnetoelectric monopoles[1]. We further develop a scheme to calculate the ME monopole in bulk periodic solids, by exploiting similarities to the ferroelectric polarization. Finally, as an example we present results for the series of lithium transition metal phosphate compounds ($LiMPO_4$, with M = Co, Fe and Ni), which include both ferromonopolar and antiferromonopolar ordered cases. We predict for the latter case a q-dependent diagonal ME effect.

[1] N . A. Spaldin et al., PRB 88, 094429 (2013)

MA 16.6 Tue 10:45 BEY 118

Different routes for enhanced control of ferroelectric polarization by magnetic field — •I. Fina[1,2], V. Skumryev[3,4], D. O'Flynn[5], G. Balakrishnan[5], N. Dix[2], J. M. Rebled[2,6], P. Gemeiner[7], X. Marti[8], F. Peiró[6], B. Dkhil[7], F. Sánchez[2], L. Fàbrega[2], and J. Fontcuberta[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Institut de Ciència de Materials de Barcelona, Catalonia, Spain — [3]Institució Catalana de Recerca i Estudis Avançats (ICREA), Catalonia, Spain — [4]Universitat Autònoma de Barcelona, Barcelona, Spain — [5]University of Warwick, Coventry, United Kingdom — [6]LENS - MIND/IN2UB, Barcelona, Spain — [7]Propriétés et Modélisation des Solides, Paris, France — [8]Faculty of Mathematics and Physics, Praha, The Czech Republic

I will focus on the direct magnetoelectric effect, control of polarization vector by magnetic field, in single-phase and composite multiferroic materials in thin film form.

In single-phase multiferroic materials, cycloidal magnet, we will see that strong coexistence of polar and non-polar regions allow large susceptibilities leading to a full control of the polarization vector by means of magnetic field [1]. In composite materials, ferromagnetic-ferroelectric heterostructures, the limiting factor is the substrate clamping effect. We will show that we can overcome this undesired effect, enhancing the presence of some small quantity of defects. These defects store the needed elastic energy, enhancing the magnetoelectric coupling, which result in huge effects near room temperature [2].

[1] I. Fina, et al., Phys. Rev. B 88, 100403(R) (2013). [2] I. Fina, et al., Nanoscale 5, 8037 (2013).

15 min. break

MA 16.7 Tue 11:15 BEY 118

Investigation of A-site Bismuth based double perovskites as potential room-temperature multiferroics — •Vikas Shabadi, Mehran VafaeeKhanjani, Mehrdad BaghaieYazdi, Aldin Radetinac, Philipp Komissinskiy, and Lambert Alff — Institute of Materials Science, Technische Universität Darmstadt, Germany

A-site Bismuth based double perovskites ($Bi_2BB'O_6$), where ferroelectricity arises from the stereochemically active $6s^2$ lone pair of electrons on the Bi^{3+} cations, provide a vital test bed to engineer room temperature multiferroicity. Here, different combinations of 3d-3d or 3d-5d cations may be introduced at the B-site in order to obtain an effective ferri/ferromagnetic moment. The 3d-3d compound Bi_2FeCrO_6 (BFCO) has drawn a heightened interest due to its large experimentally reported ferroelectricity and divergent observations of its magnetic properties. We report epitaxial BFCO thin films grown by pulsed laser deposition on single crystal $SrTiO_3(100)$ substrates. Detailed structural characterization was performed by X-ray Diffraction and the magnetic properties were studied with a SQUID magnetometer. We show that BFCO adopts a superstructure with the same unit cell as the chemically ordered double perovskite. The magnetization is a function of chemical but not of structural order.

MA 16.8 Tue 11:30 BEY 118

Room temperature magnetism and ferroelectricity in eps-Fe2O3 thin films — •I. Fina[1], M. Gich[2], A. Morelli[1], F. Sánchez[2], M. Alexe[1], J. Fontcuberta[2], and A. Roig[2] — [1]Max Planck Institute of Microstructure Physics D-06120 Hallle/Salle, Germany — [2]Institut de Ciència de Materials de Barcelona ICMAB, Consejo Superior de Investigaciones Científicas CSIC, Campus UAB 08193 Bellaterra, Catalonia, Spain

The quest for magnetoelectric multiferroics is driven by the promise of a novel generation of devices combining the best characteristics of ferromagnetic and ferroelectric materials. These cherished applications require materials displaying a substantial magnetization and electric polarization which are coupled and coexist well above room temperature. These properties are not commonly fulfilled by single phase materials and firm candidates for the development of these technologies are still sought.

In this contribution, we will report on epitaxial eps-Fe2O3 thin films grown by Pulsed Laser Deposition on (111) SrTiO3 and present recent data on its structural, magnetic and dielectric characterization. The films are ferromagnetic and ferroelectric at room temperature and display magnetization and polarization values at remanence of about 50 emu/cm3 and 1 uC/cm2 with a long retention. A magnetocapacitive response has also been detected indicating that the films present coupling between both ferroic orders.

MA 16.9 Tue 11:45 BEY 118

Time-resolved analysis of switching in spiral multiferroics — •Jonas Stein[1], Tobias Cronert[1], Jeannis Leist[2], Karin Schmalzl[3], A Agung Nugroho[4], Alexander C Komarek[5], Götz Eckold[2], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Physikalische Chemie, Universität Göttingen — [3]JCNS at ILL, France — [4]Institut Teknologi Bandung, Indonesia — [5]MPI für chemische Physik fester Stoffe

Multiferroic crystals are promising materials for future memory devices with extremely low power consumption. The rise time between two states is a crucial parameter for a possible application and was investigated in the spiral spin multiferroic $TbMnO_3$. Polarized neutron diffraction is able to determine the ratio of chiral domains, which can be controlled by an external electric field. Using the stroboscopic technique we can follow the reversion of chiral domains in the timescale of a few 100 microseconds to hours. In $TbMnO_3$ we find a clear logarithmic relation between the rise time and temperature that is fulfilled over 5 decades.

MA 16.10 Tue 12:00 BEY 118

Thermodynamic properties of the new multiferroic material $(NH_4)_2[FeCl_5(H_2O)]$ — •Matthias Ackermann[1], Daniel Brüning[2], Thomas Lorenz[2], Petra Becker[1], and Ladislav Bohatý[1] — [1]Institut für Kristallographie, Universität zu Köln, Germany — [2]II. Physikalisches Institut, Universität zu Köln, Germany

Multiferroic materials with coupled ferroelectric and (anti-)ferromagnetic order in the same phase have attracted considerable interest during the last decade. The search for new multiferroic materials is an important issue to further improve the understanding of the underlying coupling mechanisms. Here, we present a detailed investigation of the new multiferroic compound $(NH_4)_2[FeCl_5(H_2O)]$ [1]. Our measurements of pyroelectric currents reveal, that the electric polarization occuring in the antiferromagnetically ordered phase can drastically be influenced by applying magnetic fields. Based on the results of these dielectric investigations, together with measurements of thermal expansion, magnetostriction and specific heat, detailed magnetic field versus temperature phase diagrams are derived. Depending on the direction of the magnetic field up to three different multiferroic phases are identified, which are separated from the paramagnetic phase by a magnetically ordered, but non-ferroelectric phase.

This work was supported through the Institutional Strategy of the University of Cologne within the German Excellence Initiative.

[1] Ackermann M et al. 2013 *New J. Phys.* (in press, arXiv:1308.0285)

MA 16.11 Tue 12:15 BEY 118

Stoichiometric Effects on Crystal Quality in $LuFe_2O_4$ and $YbFe_2O_4$ — •Hailey Williamson[1,2], Geetha Balakrisnan[2], and Manuel Angst[1] — [1]Jülich Centre for Neutron Science JCNS-2 and Peter Grünberg Institut PGI-4, Forschungszentrum Jülich GmbH, Jülich, Germany. — [2]Department of Physics, The University of Warwick, CV4 7AL, Coventry, UK

The multiferroic rhombohedral $LnFe_2O_4$ (Ln=Lu, Y, Yb, Tm, Ho and Er) system, which can be described as stacked hexagonal Fe bilayers separated by Lu monolayers, has been in focus since the discovery of interesting magnetic and electrical characteristics in $LuFe_2O_4$. The specific CO configuration within the Fe bilayers was initially thought to produce a ferroelectricity through cross polarization of the two layers of the bilayer. However our recent investigations indicate that the CO configuration is actually non-polar. Extensive research highlighted a large sensitivity to oxygen stoichiometry, where crystals grown in an excess/deficient oxygen partial pressure environment exhibit smeared glassy magnetic transitions and diffuse CO. Through fine tuning of the atmospheric conditions, crystals exhibiting 3D CO and magnetism were produced. Interest then spread to isostructural $YbFe_2O_4$, which has currently few detailed investigations. Single crystals of $YbFe_2O_4$ were grown in four different partial pressure atmospheres to view the effects of oxygen stoichiometry on the magnetism and CO. A series of macroscopic and microscopic measurements provided a detailed look into the effects of oxygen stoichiometry on the intrinsic characteristics as well as a comparison to that of its predecessor $LuFe_2O_4$.

MA 16.12 Tue 12:30 BEY 118

Multiferroicity in Cu_2OSeO_3? — •Eugen Ruff[1], Stephan Krohns[1], Helmuth Berger[2], Peter Lunkenheimer[1], and Alois Loidl[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg — [2]Institute of Physics of Complex Matter, École Polytechnique Fédérale de Lausanne

Skyrmions are topologically stable vortex-like objects, for the first time detected in the B20 alloy MnSi [1]. Their electrical controllability via small currents qualifies skyrmions for applications in high-density magnetic storage devices. The recent discovery of magnetoelectric skyrmions in the insulating chiral magnet Cu_2OSeO_3 leads to another promising route to electrical control [2]. This system is suggested to carry a local electrical dipole, which implies that the skyrmions should be controllable by an external electrical field without losses due to Joule heating. Here we provide a thorough analysis of the magnetic and polar phases of this material, using SQUID and pyrocurrent measurements. In order to investigate the possible ferroelectric properties of Cu_2OSeO_3, we have performed dielectric spectroscopy in various magnetic fields in a broad frequency range below 70 K. Combining all these different techniques, we address the question whether Cu_2OSeO_3 is magnetoelectric or multiferroic. [1] S.Mühlbauer *et al.*, Science **323**, 915 (2009). [2] S.Seki *et al.*, Science **336**, 198 (2012).

MA 17: Spintronics (jointly with HL,TT)

Time: Tuesday 13:45–16:00 Location: HSZ 401

MA 17.1 Tue 13:45 HSZ 401

Sound Waves in a Magnon Bose Einstein Condensate — •Patryk Nowik-Boltyk[1], Oleksandr Dzyapko[1], Vladislav E. Demidov[1], Sergej O. Demokritov[1], Vasyl Tyberkevych[2], and Andrej N. Slavin[2] — [1]Institute of Applied Physics, University of Muenster, Muenster, Germany — [2]Department of Physics, Oakland University, Rochester, USA

Magnon Bose-Einstein condensation (mBEC) in Yttrium-Iron-Garnet films is a spectacular room-temperature macroscopic quantum phenomenon, which is under investigation since recently [1]. Although the basic properties of mBEC such as temporal [2] and spatial [3] coherence have extensively been studied during the last 5 years, the perturbed dynamics of the condensate have not been addressed so far. Here we report an experimental study of sound waves in a magnon gas, above and below the threshold for mBEC, performed using a space- and time-resolved Brillouin light scattering technique. The magnon gas was prepared using microwave pumping of magnons, while the sound waves were excited by, an additional, localized, oscillating, RF magnetic field. We show that at small wave vectors sound waves exhibit a linear dispersion law with a density independent group velocity, while at large wave vectors the dispersion changes from a linear dependence into a quadratic one at the threshold for mBEC. We demonstrate that this sudden change is due to an additional scattering mechanism that arises when an mBEC is formed. [1] S.O. Demokritov et al. Nature 443, 430 (2006) [2] V.E. Demidov et al. Phys. Rev. Lett. 100, 047205 (2008) [3] P. Nowik-Boltyk et al. Nature Sci. Rep. 2, 482 (2012)

MA 17.2 Tue 14:00 HSZ 401

Antiferromagnetic spintronics — •I. Fina[1,2], X. Marti[3,4,5], D. Yi[3], C. Rayan-Serrao[3], J. Liu[3], J.-H. Chu[3], S.J. Suresha[3], J. Zelezny[5], T. Jungwirth[5,6], J. Fontcuberta[3], and R. Ramesh[3] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, Halle Germany — [2]Institut de Ciencia de Materials de Barcelona, ICMAB-CSIC, 08193 Bellaterra, Spain — [3]Department of Materials Science and Engineering, University of California, Berkeley, CA 94720, USA — [4]Dept. Condensed Matter Physics Charles University in Prague — [5]Institute of Physics ASCR, v.v.i., Cukrovarnick 10, 162 53 Praha 6, Czech Republic — [6]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom

Magnetic semiconductors entwine two of the most successful concepts in both fundamental physics and industrial applications. Recently antiferromagnets have been proposed as new and atractive material systems. Antiferromagnetic spintronics have been demonstrated by the fabrication of tunnel devices, atomic-size proof-of concepts, even devices without auxiliary ferromagnetic layers. Here we present the control of the electrical conductivity of an antiferromagnetic semiconductor by manipulating the magnetic state of a contiguous ferromagnetic.

We present an oxide-based fully epitaxial heterostructure, its structural characterization and the electrical measurements showing a direct link between state of the ferromagnetic gate and ohmic resistance of the semiconductor, even displaying distinct remnant resistance states. We will also show that distinct remnant states can also been obtained at room temperature, promising potential applicability.

MA 17.3 Tue 14:15 HSZ 401

Calculating spin transport and magnetization dynamics parameters in textured magnetic materials — •Zhe Yuan — Faculty of Science and Technology, University of Twente, Enschede, The Netherlands — Institute of Physics, Johannes Gutenberg-University Mainz, Mainz, Germany

First-principles calculations allow us to understand the electronic and magnetic properties of real materials in terms of their chemical composition, atomic structure and magnetic configuration by numerically solving the quantum mechanical equations that describe the motion of the electrons. We have developed a unique first-principles formalism of scattering theory that can be used to calculate quantities such as the resistivity, Gilbert damping, and spin-transfer torque for a wide variety of material systems. In this talk, I will focus on how magnetic domain walls (DWs) modify the above transport and magnetization dynamics properties in real materials. Taking the technologically important Ni80Fe20 magnetic alloy, as an example, we have studied the change in its resistance due to the presence of a DW. The Gilbert damping in a DW is found to be anisotropic and drastically enhanced by the magnetization gradient, which has significant effects on field- and/or current-driven DW motion.

MA 17.4 Tue 14:30 HSZ 401

Spin Solar Cell for Spin Injection into Semiconductors. — Bernhard Endres, Mariusz Ciorga, Maximilian Schmid, Martin Utz, Dominique Bougeard, Dieter Weiss, Christian Back, and •Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg

Optical spin pumping allows to create spin-polarized carriers in III-V semiconductors, but requires circularly polarized light of a well-defined wavelength. Here we describe a spin-generating solar cell without such limitations [1,2]. The device consists of a p-n junction with highly n-doped GaAs at the n-side and ferromagnetic (Ga,Mn)As at the p-side. Illuminating this junction creates a photo-voltage causing electrons to tunnel across the narrow barrier from the n-GaAs into the (Ga,Mn)As. Due to the spin-dependent tunneling probability a spin accumulation occurs in the n-GaAs. This spin solar cell effect is demonstrated with a laser beam generating electron-hole pairs and detecting the spin accumulation via the polar magneto-optic Kerr effect and by measuring non-local voltages. On applying a large negative bias the sign of the photo-induced spin polarization is reversed as expected due to the suppression of the tunneling current through a wider barrier. This mode of operation corresponds to a spin photodiode. The spin solar cell effect should equally work for metallic ferromagnets with a high Curie temperature and allow to convert unpolarized light into a spin current also in semiconductors without a direct band gap like Si and Ge.

[1] B. Endres et al., Nature Commun. 4, 2068 (2013).
[2] R. Jansen, Nature Mater. 12, 779 (2013)

MA 17.5 Tue 14:45 HSZ 401

Magnetic anisotropy in CoFe/MgO/CoFe magnetic tunnel junctions with ultrathin electrode layers and its composition dependence — •Jia Zhang, Christian Franz, Michael Czerner, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, Giessen, Germany

MgO based magnetic tunnel junctions (MTJs) with ultrathin CoFeB magnetic electrodes can have perpendicular magnetic anisotropy and a low switching current. In addition, MgO-MTJs with perpendicular anisotropy may also be easier to switch by thermal spin transfer torque and may pave its potential application in Spincaloritronics. In this talk, the magnetic anisotropy in CoFe/MgO/CoFe-MTJs on different substrates for instance Cu, Au, MgO etc. and different CoFe alloy composition are discussed using full relativistic Korringa-Kohn-Rostoker and coherent potential approximation (CPA) first-principles calculations. The magnetic anisotropy energy (MAE) in CoFe/MgO/CoFe-MTJs was calculated by employing magnetic force theory. The calculated MAE in Co_xFe_{1-x}/MgO/Co_xFe_{1-x}-MTJs decreased with the increasing of Co composition. The $d_{zx}(d_{yz})$ and $d_{xy}(d_{x^2-y^2})$ orbital and its evolution in the spin down channel was found to be responsible for the rise of magnetic anisotropy and the composition dependence. The shape anisotropy energy was also calculated and thus the phase diagram with perpendicular anisotropy versus composition and thickness was determined. Finally, we will give a brief discussion on magneto resistance and spin-transfer torque in CoFe/MgO/CoFe-MTJs with perpendicular easy axis.

MA 17.6 Tue 15:00 HSZ 401

Magnetic and electronic properties of $Ni_2S_2O_2N_6C_{57}H_{78}P^+$ on Au(111) — •Kai Trepte, Claudia Martin, and Jens Kortus — Institute of Theoretical Physics, TU Bergakademie Freiberg, Germany

The electronic and magnetic properties of a Ni^{2+} dimer including a PPh_3- ligand in contact with a Au(111) surface have been measured [1]. We will present theoretical calculations using DFT (with and without van der Waals interactions) including only the PPh_3- ligand binding on the Au(111) surface in order to determine the magnetic exchange and anisotropy. We will discuss charge transfer and the bonding situation for the favored binding position in more detail. Finally we will compare these results with a calculation of the dimer on the surface including geometry changes and charge transfer.

[1] M. Golecki et al. Chemisorption of exchange-coupled $[Ni_2L(dppba)]^+$ complexes on gold by using ambidentate 4-(diphenylphosphino)benzoate co-ligands. *Chemistry - A European Journal*, 19(24):7787-7801, 2013.

MA 17.7 Tue 15:15 HSZ 401

Manipulating the coupling between metal and molecule in hybrid structures by changing of organic anchor groups — •Simon Liebing, Torsten Hahn, and Jens Kortus — Institut of Theoretical Physics, TU Bergakademie Freiberg, 09599 Freiberg

There are theoretical and experimental works which propose to the use of amino anchor groups [1] instead of the more often used thiol [2] ones. So far there is no systematic study comparing the properties of different anchor groups. The present study investigates the properties of amino, cyano, furan, hydroxyl, pyrol thiol and thiophen in a break junction like geometry. The anchor groups are attached to a novel molecular system based on an anthraquinone-core with conjugated spacers to form a model system. These anchor groups include also some that could form π-like bonds and allow fully and cross-conjugated electron systems.

The molecular structures are constructed with Avogadro [3] and optimized by all-electron DFT-code NRLMOL [4]. The device structures are than optimized with the GPAW program package [5] an plane wave augmented wave again. The same software is used for the calculation of the transport properties by means of the NEGF-formalism.

References

1 Angela. D. et. al. Nano Letters 10, no. 7 (2010), 2 Markussen, T. et al. JCP 132 , 224104 (2010), 3 Hanwell, M. D. et al. Journal of Cheminformatics 4, 17 (2012), 4 Pederson, M. et. al. Phys. Status Solidi b 217, 197. (2000), 5 Enkovaara, J. et al. Journal of Physics: Condensed Matter 22, 253202 (2010)

MA 17.8 Tue 15:30 HSZ 401

Barrier dependent tunneling magnetoresistance in carbon nanotubes — •Carola Meyer[1,2], Cate Morgan[1,2], Dominik Metten[3], Sebastian Heedt[1,2], Thomas Schäpers[1,2], and Claus M. Schneider[1,2] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA - Fundamentals of Future Information Technologies — [3]Institut de Physique et Chimie des Matériaux de Strasbourg and NIE, UMR 7504, Université de Strasbourg and CNRS, France

Carbon nanotubes (CNTs) are a material of interest in spintronics, because in addition to exhibiting ballistic transport, the low atomic number and low abundance of ^{13}C nuclei in CNTs is expected to lead to low spin orbit coupling and hyperfine interaction indicating a long spin relaxation time. However, the size of the magnetoresistance (MR) observed depends strongly on the current regime and on the type of CNT device measured. In the single-electron-tunneling regime, typically only a few percent MR can be reached. MR in multiwalled CNTs with a large diameter has shown to be as large as 60% for contacts with high polarization [1].

We present a way to compare the MR of different devices from single-wall and multiwalled CNTs with respect to the current regime. Temperature dependent data confirm tunneling MR as the main effect. The size of the MR measured depends on the strength of the tunnel barrier and follows the Slonczewski model. Finally, the presence of the Hanle effect proves successful spin injection.

[1] L. E. Hueso et al., Nature 445, 410 (07)

MA 17.9 Tue 15:45 HSZ 401

Transport properties of multiferroic tunnel junctions in an embedded Green-function approach — •Andera 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

Multiferroics tunnel junctions are promising structures for spintronic devices due to their transport properties. From the theoretical point of view the study of transport in Metal/Ferroelectric/Metal needs to deal with several degrees of freedom. Structural distortions at the interface, polarization and magnetization directions, presence of oxides at the interface and strong correlations must be taken into account. We focus on the tunneling properties of a Fe/BTO/Fe barrier obtained in an embedded Green-function approach [1] implemented with the framework of the full-potential linearized augmented plane-wave (FLAPW) method `FLEUR` [2]. Electronic charge self-consistency is achieved in the same approach. 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 18: Magnetic Coupling Phenomena

Time: Tuesday 14:00–15:45 Location: HSZ 403

MA 18.1 Tue 14:00 HSZ 403

Exchange Bias driven by Dzyaloshinskii-Moriya interactions — •Rocio Yanes[1], Jerome Jackson[2], Laszlo Udvardi[3], Laszlo Szunyogh[3], and Ulrich Nowak[1] — [1]Universität Konstanz, Konstanz, Germany — [2]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [3]Budapest University of Technology and Economics, Budapest, Hungary

The exchange bias (EB) effect is an effective unidirectional anisotropy in a heterogeneous magnetic system that leads to a shift in the hysteresis loop. It is widely accepted that the EB is related to the nature of coupling between a ferromagnet (FM) and an antiferromagnet (AFM).

We studied the origin of EB in a metallic $IrMn_3$/Co(111) bilayer, using multiscale modeling, from ab-initio to localized spin model simulations. $IrMn_3$ is a frustrated antiferromagnet which presents a strong second order effective anisotropy and a high Néel temperature. It exhibits a triangular magnetic ground state within the (111) plane. When this alloy is capped by a Co layer, sizable Dzyaloshinskii-Moriya (DM) interactions arise owing to the breaking of symmetry at the interface [1]. DM interactions between the Co and Mn atoms result in an effective DM field on the Co spins, oriented normal to the interface.

A detailed analysis of the hysteresis loops reveals that the DM interactions across the $IrMn_3$/Co interface are the main source of perpendicular EB in this system [2]. This work was partially supported by the FP7-NMP-2013-EU-Japan project HARFIR.

[1] L. Szunyogh et. al., Phys. Rev. B 83, 024401 (2011).
[2] R. Yanes et. al., Phys. Rev. Lett, 111, 217202 (2013).

MA 18.2 Tue 14:15 HSZ 403

Exchange bias up to room temperature in the antiferromagnetic bulk hexagonal Mn3Ge — •Jin-Feng Qian, Ajaya Nayak, Guido Kreiner, Walter Schnelle, and Clauida Felser — Nöthnitzer Str. 40, 01187 Dresden , Germany

This work reports an exchange bias (EB) effect up to room temperature in the binary intermetallic bulk compound Mn3.04Ge0.96. The sample annealed at 700 K crystallizes in a tetragonal structure with ferrimagnetic ordering, whereas, the sample annealed at 1073 K crystallizes in a hexagonal structure with antiferromagnetic ordering. The hexagonal Mn3.04Ge0.96 sample exhibits an EB of around 70 mT at 2 K that continues with a non-zero value up to room temperature. The exchange anisotropy is proposed to be originating from the exchange interaction between the triangular antiferromagnetic host and the embedded ferrimagnetic like clusters. The ferrimagnetic clusters develop when excess Mn atoms occupy empty Ge sites in the original triangular antiferromagnet structure of Mn3Ge.

MA 18.3 Tue 14:30 HSZ 403

Mapping techniques with MOKE on FeMn/Co-exchange bias samples — Mathias Schmidt, Joachim Gräfe, Eberhard Goering, and •Gisela Schütz — Max-Planck-Institut für Intelligente Systeme, Heisenbergstr. 3, 70569 Stuttgart

Exchange bias (EB)-systems are very important for several applications in the area of magnetic storage and spintronics. Inside that class of materials, FeMn/Co thin films are one of the most prominent examples. We used molecular beam epitaxy (MBE) to produce FeMn/Co-systems on (100)-MgO substrates. Since the EB effect is very sensitive to sample properties like layer thickness, roughness and also layer composition which can significantly deviate laterally on co-evaporated films like FeMn, a fast and spatially resolving measuring technique is very useful for a fast and reliable local characterization of the magnetic reversal process. For that issue, we used two applications of the magneto-optic Kerr effect (MOKE), delivering a sub-micrometer resolution and the possibility to measure a full hysteresis loop of a magnetic system in a timescale of milliseconds. At first, we will present maps of magnetic properties like exchange bias and coercive fields using the recently developed sweep-map-technique , an extremely fast method for magnetic sample characterization on a lateral scale up to several millimeters. Furthermore, we will show several examples of measurements with the FORC (first-order reversal-curve)-technique, delivering a dataset of all magnetic states of a system in a two dimensional contour plot and therefore revealing the distribution of local coercive fields and interactions (i.e. exchange bias) in our samples.

MA 18.4 Tue 14:45 HSZ 403

Temperature dependent study of the magneto-electric coupling in $BiFeO_3/La_{0.7}Sr_{0.3}MnO_3$ (BFO/LSMO) artificial multiferroic heterostructures by high resolution x-ray microscopy — •S. Finizio[1], C. Mix[1], M. Buzzi[2], F. Kronast[3], F. Nolting[2], G. Jakob[1], and M. Kläui[1] — [1]Institut für Physik, Johannes Gutenberg Universität, 55128 Mainz, Germany — [2]Swiss Light Source, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland — [3]Helmholtz Zentrum für Materialien und Energie GmbH, 12489 Berlin, Germany

Artificial multiferroic systems, where coupling between the ferroelectric and ferromagnetic order is expected, have been object of intense research in the last years. One of such systems is the artificial multiferroic heterostructure BFO/LSMO, which combines BFO (ferroelectric and antiferromagnetic) with LSMO (ferromagnetic), for which an exchange-bias driven coupling, which could allow for the magnetic switching of the LSMO by switching the ferroelectric polarization in the BFO, is expected. In this contribution, a temperature-dependent analysis of the artificial multiferroic heterostructure BFO/LSMO has been carried out with high resolution x-ray microscopy. It was observed that the magnetization of the LSMO layer changes with the temperature, switching from an elongated stripe-like domain structure, typical of LSMO thin films without BFO, to a grain-like domain structure, which resembles the antiferromagnetic domains of the BFO layer. This leads thus to the observation that the BFO layer influences the magnetic structure of the ferromagnetic LSMO.

MA 18.5 Tue 15:00 HSZ 403

Exchange bias and long-range interlayer coupling in Co/Mn/Co trilayers — •Bin Zhang, Chii-Bin Wu, and Wolfgang Kuch — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Epitaxial Co/Mn/Co trilayers with a wedged Mn layer were grown on Cu(001) to study the exchange bias and interlayer coupling by magneto-optical Kerr effect measurements. The coercivity of the trilayers as a function of thickness starts to increase at around 4.7 ML. Exchange bias appears around 10 ML. The hysteresis loops exhibit two separate steps above 10 ML Mn thickness, corresponding to the switching of the two FM layers. From minor loop measurements both the coercivity and the remanence of the top Co layer have been determined. Both show an oscillation with 1 ML period as a function of the Mn layer thickness. We attribute this to roughness oscillations at the upper interface due to the layer-by-layer growth of Mn on Co. The magnetic coupling of the top and bottom Co layer through the Mn layer exhibits an oscillation with a period of 2 ML Mn thickness above a thickness of 10 ML. In addition, a long-period interlayer coupling of the two FM layers with antiparallel coupling maxima at Mn thicknesses of 2.5, 8.2, and 13.7 ML is observed and attributed to RKKY-type coupling. There is no oscillatory behavior of the exchange bias in the bottom layer.

MA 18.6 Tue 15:15 HSZ 403

Thickness dependent exchange bias in martensitic phase of Ni-Mn-Sn thin films — •Anna Behler[1,2], Niclas Teichert[3], Biswanath Dutta[4], Anja Waske[1], Tilmann Hickel[4], Alexander Auge[3], Andreas Hütten[3], and Jürgen Eckert[1,5] — [1]IFW Dresden, Institute for Complex Materials, 01171 Dresden, Germany — [2]Department of Physics, Institute for Solid State Physics, Dresden University of Technology, 01062 Dresden, Germany — [3]Department of Physics, Thin Films and Physics of Nanostructures, Bielefeld University, 33501 Bielefeld, Germany — [4]Max-Planck Institut für Eisenforschung, 40237 Düsseldorf, Germany — [5]Institute of Materials Science, Dresden University of Technology, 01062 Dresden, Germany

In the low temperature martensitic phase of epitaxial Ni-Mn-Sn thin films we found an exchange bias (EB) effect after field cooling and zero field cooling (ZFC) the system. The high values of the thickness dependent EB after ZFC can be retained down to very small thicknesses. In comparison for a Ni-Mn-Sn thin film, which differs in composition and therefore does not undergo a martensitic transition, no exchange bias is observed. The EB behavior is attributed to the unidirectional anisotropy due to the coupling between ferromagnetic (FM) and antiferromagnetic (AFM) interactions. Our magnetization measurements suggest that a significant interplay between FM and AFM regions is only present in the low temperature martensitie. This is qualitatively supported by ab initio calculations showing the AFM order is stabilized in this phase compared to the austenitic state. Particular attention is paid to the need of the martensitic phase of Ni-Mn-Sn for EB.

MA 18.7 Tue 15:30 HSZ 403

Annealing temperature dependence and stability towards external magnetic fields of the exchange bias field in $Mn_{83}Ir_{17}/Co_{70}Fe_{30}$-bilayers — •Timo Ueltzhöffer, Alexander Gaul, Sebastian Kübler, Dennis Holzinger, and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

The annealing temperature dependence of the exchange bias field of sputter deposited $Mn_{83}Ir_{17}/Co_{70}Fe_{30}$-bilayers and their stability towards external magnetic fields at different temperatures is studied. By further developing the York protocol (YP) [1], a measurement sequence for reproducible determination of the blocking temperature, reproducible results for the characteristic blocking temperature ($T_{B,YP}$ = 458 K) as well as the activation temperature (T_{act} = 360 K) could be determined. With the experimental results an estimate of the grain size distribution in the antiferromagnet was achieved.

[1] K. O'Grady, L.E. Fernandez-Outon and G. Vallejo-Fernandez, J. Magn. Magn. Mater. 322, 883 (2010)

MA 19: Poster I

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

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

MA 19.1 Tue 13:00 P1

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

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

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

The relevance of these results to experiments is also discussed.

MA 19.2 Tue 13:00 P1

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

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

MA 19.3 Tue 13:00 P1

$[Cu_2^{II}(NGuaS)_2Cl_2]$: Antiferromagnetic coupling and optical response, a broken symmetry DFT analysis — •Matthias Witte, Uwe Gerstmann, Eva Rauls, and Wolf Gero Schmidt — University Paderborn, Germany

Copper enzymes are of utter importance for biochemical processes in nature. Their capability of hydroxylating phenols to catechols, for example, is essential for the tyrosinase process. Hence understanding their electronic structure and rationalizing their spectroscopic fingerprints are primary goals for theoretical chemistry. However the computation of their structural and electronic properties turns out to be quite challenging and typically smaller model systems are investigated showing similar functionalities. Gerald Henkel and co-workers succeeded in the previously unknown chloride-induced disulfide thiolate interconversion, leading from the copper(I) disulfide complex cation $[Cu_2^{I}(NGuaS)_2]^{2+}$ to the electrically neutral copper(II) thiolate species $[Cu_2^{II}(NGuaS)_2Cl_2]$. [1] We analyse the electronic groundstate which is antiferromagnetically coupled by the use of density functional theory. We employ the B3LYP hybrid functional and an atom-centered cc-pVDZ basis set. The optical spectra are calculated using the TDDFT approach. In order to rationalize the antiferromagnetic coupled groundstate we analyze the electronic structure in detail and trace it to a more favorable Coulomb interaction.

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

MA 19.4 Tue 13:00 P1

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

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

MA 19.5 Tue 13:00 P1

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

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

MA 19.6 Tue 13:00 P1

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

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

[1] Microstructure and magnetic properties of strained Fe3O4 films Chen, Y. Z. et al., Journal of Applied Physics, 103, 07D703 (2008).
[2] New Class of Materials: Half-Metallic Ferromagnets de Groot, R. A. et al. Phys. Rev. Lett. 50, 2024-2027 (1983)

MA 19.7 Tue 13:00 P1

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

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

MA 19.8 Tue 13:00 P1

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

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

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

MA 19.9 Tue 13:00 P1

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

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

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

MA 19.10 Tue 13:00 P1

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

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

MA 19.11 Tue 13:00 P1

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

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

MA 19.12 Tue 13:00 P1

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

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

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

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

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

MA 19.13 Tue 13:00 P1

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

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

MA 19.14 Tue 13:00 P1

Magnetic linear dichroism in angular resolved photoemission of the valence band of Co (0001) thin films — •Tobias Löffler[1], Torsten Veltum[1], Sven Döring[2], Lukasz Plucinski[2], and Mathias Getzlaff[1] — [1]Institut für Angewandte Physik,

Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf — [2]Peter Grünberg Institut PGI-6, Forschungszentrum Jülich, 52428 Jülich

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

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

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

MA 19.15 Tue 13:00 P1

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

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

MA 19.16 Tue 13:00 P1

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

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

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

MA 19.17 Tue 13:00 P1

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

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

MA 19.18 Tue 13:00 P1

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

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

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

MA 19.19 Tue 13:00 P1

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

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

MA 19.20 Tue 13:00 P1

Nanoscale sensing of a magnetic topology at room & low

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

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

MA 19.21 Tue 13:00 P1

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

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

MA 19.22 Tue 13:00 P1

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

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

MA 19.23 Tue 13:00 P1

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

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

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

MA 19.24 Tue 13:00 P1

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

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

MA 19.25 Tue 13:00 P1

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

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

MA 19.26 Tue 13:00 P1

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

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

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

MA 19.27 Tue 13:00 P1

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

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

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

MA 19.28 Tue 13:00 P1

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

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

MA 19.29 Tue 13:00 P1

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

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

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

MA 19.30 Tue 13:00 P1

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

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

MA 19.31 Tue 13:00 P1

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

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

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

MA 19.32 Tue 13:00 P1

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

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

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

MA 19.33 Tue 13:00 P1

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

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

MA 19.34 Tue 13:00 P1

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

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

MA 19.35 Tue 13:00 P1

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

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

MA 19.36 Tue 13:00 P1

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

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

MA 19.37 Tue 13:00 P1

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

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

MA 19.38 Tue 13:00 P1

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

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

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

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

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

MA 19.39 Tue 13:00 P1

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

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

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

MA 19.40 Tue 13:00 P1

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

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

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

MA 19.41 Tue 13:00 P1

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

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

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

MA 19.42 Tue 13:00 P1

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

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

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

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

MA 19.43 Tue 13:00 P1

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

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

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

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

MA 19.44 Tue 13:00 P1

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

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

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

MA 19.45 Tue 13:00 P1

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

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

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

MA 19.46 Tue 13:00 P1

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

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

MA 19.47 Tue 13:00 P1

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

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

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

MA 19.48 Tue 13:00 P1

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

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

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

MA 19.49 Tue 13:00 P1

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

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

MA 20: Magnetic Adatoms on Surfaces (with O)

Time: Tuesday 15:00–16:00 Location: BEY 118

Invited Talk MA 20.1 Tue 15:00 BEY 118

Manipulating the magnetic properties of single atoms on surfaces — •Alexander Ako Khajetoorians — Institute of Applied Physics, Hamburg University, Hambury, 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 [4-6] on metallic surfaces [1,7]. 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 hydrogenation on the magnetic state of such atoms. Finally, I will discuss investigations of the magnetization dynamics [6] of coupled spins as probed with spin-resolved STM. [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, 339, 55 (2013), [7] A.A.K., et al, PRL, 111, 126804 (2013).

Invited Talk MA 20.2 Tue 15:30 BEY 118

Spin Interaction of Atoms studied with Ultrafast STM — •Sebastian Loth — Max Planck Institute for the Structure and Dynamics of Matter, Hamburg — Max Planck Institute for Solid State Research, Stuttgart

Spin-dependent interaction between magnetic atoms produces a variety of quantum phenomena ranging from superposition ground states and magnetic tunneling to quantum criticality. In this talk we will show that time-resolving scanning tunneling microscopy (STM) makes it possible to study these effects experimentally.

We engineer experimental representations of different Spin Hamiltonians by assembling transition metal atoms into arrays of different shape and elemental composition on the surface of a thin insulator/metal substrate. Inelastic electron tunneling and all-electronic pump-probe spectroscopy at GHz frequencies quantifies the energy level structure, energy loss mechanisms and spin lifetimes of the interacting spins [Science 329, 1628 (2010)]. Using this technique we identified a new approach to suppress magnetic tunneling in antiferromagnetic spin chains triggered by a phase transition from a singlet ground state to classical magnetic states [Science 335, 196 (2012)]. Magnetic tunneling can also be enhanced by combining atoms with different spin magnitude into chains that exhibit spin-correlated singlet ground states even at several nanometers length.

The time-domain information further enables non-local measurements of magnetic states shedding light onto possible pathways to controllably interact with atom-sized quantum spins.

MA 21: Multiferroics II (jointly with DF, DS, KR, TT)

Time: Wednesday 9:30–13:00 Location: HSZ 04

MA 21.1 Wed 9:30 HSZ 04

An Engineered Polar Oxide Heterostructure Built from Isosymmetric Magnetically Ordered Components — •Matthew S Dyer[1], Jonathan Alaria[1], Pavel Borisov[1,5], Troy D Manning[1], Serban Lepadatu[2], Markys G Cain[2], Elena D Mishina[3], Natalia E Sherstyuk[3], N A Ilyin[3], Joke Hadermann[4], David Lederman[5], John B Claridge[1], and Matthew J Rosseinsky[1] — [1]University of Liverpool, Liverpool, UK — [2]National Physical Laboratory, Teddington, UK — [3]Moscow State Technical University, Moscow, Russia — [4]University of Antwerp, Antwerp, Belgium — [5]West Virginia University, Morgantown, USA

Theory predicts that certain layered heterostructures consisting of perovskite blocks have non-centrosymmetric structures. The breaking of spatial inversion symmetry arises through a combination of octahedral tilting and A site ordering. Following this prediction, we grow a thin-film of the $[(YFeO_3)_5(LaFeO_3)_5]_{40}$ heterostructure using RHEED monitored pulsed layer deposition. Polar domains are present in the thin-film, as demonstrated by second harmonic generation and piezoelectric force microscopy measurements. We experimentally confirm that the heterostructure is also magnetically ordered at room temperature with a finite magnetization, retaining the magnetic structure of the individual $YFeO_3$ and $LaFeO_3$ components.

MA 21.2 Wed 9:45 HSZ 04

First-principles study of the $BaTiO_3/BaFeO_3$ perovskite interface — •Igor Maznichenko[1], Sergey Ostanin[2], Arthur Ernst[2], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

Epitaxial growth can combine a robust ferroelectric, such as $BaTiO_3$, and strong ferromagnets into the so called composite multiferroic films. The switching properties of artificial multiferroics sandwiched between metallic contacts make them excellent candidates for the room temperature four-state memories.

Regarding the ferromagnetic side of composite multiferroics, we suggest to use the cubic perovskite $BaFeO_3$ whose epitaxial growth has been recently reported. Here, from the basis of *ab-initio* electronic structure calculations, within the Korringa-Kohn-Rostoker method, we study the magnetic properties of bulk $BaFeO_3$. The approach allows us to accurately monitor the evolution of the Curie temperature upon both the tetragonal distortions and presence of oxygen vacancies. Finally, we examine magnetoelectricity at the $BaTiO_3/BaFeO_3$ interface.

MA 21.3 Wed 10:00 HSZ 04

Behaviour of Raman modes in $BiFeO_3$ epitaxial thin films with respect to azimuthal orientation — •Andreas Talkenberger[1], Cameliu Himcinschi[1], Ionela Vrejoiu[2,3], Florian Johann[2], and Jens Kortus[1] — [1]TU Bergakademie Freiberg, Institute of Theoretical Physics, Leipziger Str. 23, D-09596 Freiberg, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle, Germany — [3]Max Planck Institute for Solide State Research, Heisenbergstr. 1, D-70569 Stuttgart, Germany

$BiFeO_3$ (BFO) is an interesting candidate for multiferroic applications. In this work we focus on the Raman spectroscopic investigation of epitaxially grown thin films of BFO by pulsed laser deposition on different substrates, belonging to the group of scandates ($DyScO_3$, $SmScO_3$, $GdScO_3$). The Raman spectra were recorded using the 442 nm emission line of a He-Cd laser. Some phonon modes show changes in the position, full width at half maximum (FWHM) and intensity depending on the azimuthal angle. We found a 90 degree periodicity of the peak position and of the FWHM for particular modes. For both parallel and crossed polarisation the four maxima in positions correspond to the minima in FWHM. Such a behaviour can be explained considering a twin family of domains with a very well defined orientation to each other. Our results are supported by piezoresponse-force microscopy and X-ray diffraction measurements as well.

MA 21.4 Wed 10:15 HSZ 04

$BiFeO_3/LaFeO_3$: a magnetoelectric multiferroic — •Zeila Zanolli[1,3], Jacek Wojdel[2], Jorge Iniguez[2], and Philippe Ghosez[3] — [1]Forschungszentrum Jülich, PGI and IAS, Jülich, Germany — [2]ICMAB-CSIC, Bellaterra, Spain — [3]Université de Liège, Physics Department, Lieǵe, Belgium

Transition-metal oxides of perovskite structure present a wide variety of physical properties. In particular, there is a strong interest in multiferroic materials that are simultaneously ferroelectric and magnetic (*magnetoelectrics*). Due to the scarcity of natural magnetoelectric multiferroics and thanks to recent advances in epitaxial growth techniques, designing new magnetoelectric multiferroic heterostructures is a promising way to succeed in this quest.

First-principles techniques are used to investigate electric control of the magnetization in the $BiFeO_3/LaFeO_3$ perovskite oxide superlattice (SL) on a (001)-$SrTiO_3$ substrate. Our results [1] show that the $BiFeO_3/LaFeO_3$ SL exhibits a trilinear coupling of a polar mode with two different rotations of the oxygen cages (*hybrid improper ferroelectricity*). Non-collinear spin calculations reveal that the ferroelectric ground state also presents weak ferromagnetism with easy axis along the [1 -1 0] direction. The microscopic mechanism allowing one to manipulate the magnetization with an electric field in such systems is presented and its dependence on strain and chemical substitution is discussed. The $BiFeO_3/LaFeO_3$ SL is found to be a good candidate to attain electric switching of magnetization at room temperature.

[1] Phys. Rev. B **88**, 060102(R) (2013)

MA 21.5 Wed 10:30 HSZ 04

The influence of strain on the optical properties of pseudo-tetragonal $BiFeO_3$ thin films — •Cameliu Himcinschi[1], Akash Bhatnagar[2], Andreas Talkenberger[1], Dietrich R.T. Zahn[3], Jens Kortus[1], and Marin Alexe[2,4] — [1]TU Bergakademie Freiberg, Institute of Theoretical Physics, D-09596 Freiberg, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle, Germany — [3]Semiconductor Physics, Technische Universität Chemnitz, D-09107 Chemnitz, Germany — [4]Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom

Tetragonally distorted $BiFeO_3$ recently attracted a lot of attention because of its interesting multiferroic properties and the larger spontaneous polarization as compared to its rhombohedral counterpart. Highly strained (when grown on $LaAlO_3$ substrates) and nearly pseudomorphic (when grown on $TbScO_3$ substrates) $BiFeO_3$ films were deposited by pulsed laser deposition. The symmetry of the tetragonally distorted $BiFeO_3$ films is discussed based on polarisation dependent Raman measurements and the comparison with Raman spectra measured for films deposited on $TbScO_3$. The evaluation of ellipsometric spectra reveals that the films deposited on $LaAlO_3$ are optically less dense and the dielectric function is blue-shifted by more than 0.3 eV as compared to the films deposited on $TbScO_3$. By analyzing the absorption edge using a bandgap model, bandgaps of 3.10 eV and 2.75 eV were determined for the films deposited on $LaAlO_3$ and $TbScO_3$, respectively. This work is supported by the German Research Foundation DFG HI 1534/1-1.

MA 21.6 Wed 10:45 HSZ 04

Electrically induced magnetic transiton at the LSMO/BTO interface — •Markus Schmitz, Alexander Weber, Paul Zakalek, Markus Waschk, and Thomas Brückel — Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich 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. 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 crystalline quality of the surface was investigated by LEED and Atomic Force Microscopy. The structural characterization was carried out by X-ray reflectometry and diffraction. We could prove the possibility to electrically polarize $BaTiO_3$ substrates due to an applied voltage of 400V by optical methods. The macroscopic magnetic properties were determined by MOKE and SQUID magnetometry. The magnetic formation at the interface with respect to the polarization of the $BaTiO_3$ was investigated by Polarized Neutron reflectometry measurements performed at MARIA (FRM II).

15 min. break

MA 21.7 Wed 11:15 HSZ 04

Growth and structure characterization of double perovskite Sr2FeMoO6 thin films — •Hakan Deniz[1], Dietrich Hesse[1], Marin Alexe[1], Robert Lowndes[2], and Lucian Pintilie[2] — [1]Max-Planck Institute of Microstructure Physics, Weinberg 2, D-06120, Halle (Saale), Germany — [2]National Institute of Materials Physics, Atomistilor 105bis, Magurele 077125, Romania

The double perovskite Sr2FeMoO6 (SFMO) has drawn considerable attention recently owing to some of its unique features such as high Curie temperature (˜410K) and half-metallic ferrimagnetic nature with a high saturation moment of 4μB. The low-field room temperature magnetoresistance observed in SFMO makes it an attractive candidate for oxide spintronics applications. However, the broad distribution of results reported so far on SFMO films suggests that an optimal structure is attainable only within a narrow window of growth conditions; and magnetic/transport properties are highly akin to Fe and Mo atomic site disorder. Pulsed laser deposition was employed to grow SFMO thin films on vicinal SrTiO3 substrates from a custom-made stoichiometric target using argon as ambient gas. X-ray diffraction data revealed that the SFMO films were grown epitaxially with respect to the substrate, including, however, a small percentage of secondary phases. The morphology of the films shows flat plains with embedded grain- or needle-like structures, which are most likely the result of spurious phases. The nature of these defects and their interfaces with the SFMO matrix are under investigation by transmission electron microscopy. This work is supported by the EU-FP7 project IFOX.

MA 21.8 Wed 11:30 HSZ 04

Magnetic Anisotropy in Multiferroic Lu_2MnCoO_6 — •Martin Lonsky[1], Merlin Pohlit[1], María Antonia Señarís Rodríguez[2], and Jens Müller[1] — [1]Physikalisches Institut, Goethe-Universität, Frankfurt (M), Germany — [2]Dpto. Química Fundamental U. Coruña, Coruña, Spain

Lu_2MnCoO_6 recently has been introduced as a new type-II multiferroic with ferroelectricity due to charge ordering and magnetostriction related to magnetic Mn^{4+} and Co^{2+} ions which are arranged alternately in the form of Ising chains along the c-axis of the crystal [1]. The magnetic properties, however, remain puzzling, which in particular is due to the lack of measurements on single crystals, that have not yet successfully been synthesized. Here, we present for the first time measurements of the magnetic anisotropy by employing micro-Hall magnetometry on a few micrograins of dimensions $\sim 1\,\mu$m only. Our results reveal a strong dependence of magnetic hysteresis on temperature and the applied field direction. This anisotropy is also reflected in the observation of a variety of unusual effects as for instance wasp-waisted hysteresis loops, sharp jumps in magnetization at about $T = 300\,$mK and an exchange bias, ocurring in each case in only one field direction. Additionally, the observation of a pronounced maximum in the coercive field at $T_{SF} \sim 12\,$K indicates a significant change in the spin dynamics of the system below T_{SF}, similar to the behavior of the related compound $Ca_3Co_{2-x}Mn_xO_6$ ($x \approx 0.95$) [2].

[1] S. Yáñez-Vilar et al., Phys. Rev. B. 84, 134427 (2011).
[2] T. Lancaster et al., Phys. Rev. B 80, 020409 (2009).

MA 21.9 Wed 11:45 HSZ 04

The multiferroic $CuCrO_2$ compound: interlayer exchange and domain population — •Matthias Frontzek — Laboratory for Neutron Scattering, Paul Scherrer Institut, 5232 Villigen-PSI, Switzerland

Multiferroic materials have become of interest for their unusual low-temperature properties in general, and the tunability of the magnetic structure through an electric field and the electric polarization through a magnetic field in particular. The most promising candidates for such controllable multiferroics have been found among the materials with inherent geometric magnetic frustration.

Among these, the delafossite $CuCrO_2$, which crystallizes in the rhombohedral $R\overline{3}m$ space group, is a multiferroic compound with an apparent strong coupling of spin and charge. In contrast to other multiferroic compounds $CuCrO_2$ shows a spontaneous electric polarization upon antiferromagnetic ordering without an accompanying structural phase transition, thus the magnetic ordering alone breaks the inversion symmetry. The peculiar magnetic structure of $CuCrO_2$ allows the direct quantitative analysis of the domain population.

In our contribution, we present a detailed study on $CuCrO_2$ single crystals using neutron diffraction in applied electric and magnetic fields. With the fields we were able to tune the multiferroic states in $CuCrO_2$ and could directly relate them to the underlying domain physics. Our results allow the re-interpretation of macroscopic measurements and show that the $p-d$ hybridization is the dominant spin-charge coupling mechanism.

MA 21.10 Wed 12:00 HSZ 04

Structure and Magnetic Coupling in $YBaFeCuO_5$ — •Andrea Scaramucci[1], Mickael Morin[2], Ekaterina Pomjakushina[2], Marek Bartkowiak[2], Denis Sheptyakov[2], Lukas Keller[2], Juan Rodriguez-Carvajal[3], Michel Kenzelmann[2], Kazimierz Conder[2], Marisa Medarde[2], and Nicola A. Spaldin[1] — [1]Materials Theory, ETH-Zurich, Zurich, Switzerland — [2]Paul Scherrer Institute, Villigen, Switzerland — [3]Institute Laue Langevin, Grenoble, France

We theoretically study the structure and exchange couplings in multiferroic $YBaFeCuO_5$ (YBFCO). Using density functional theory we calculate energies of configurations with various Fe^{3+}/Cu^{2+} orderings in the bilayered perovskite structure of YBFCO. We find that configurations with different distribution of Fe^{3+} and Cu^{2+} ions fall into two groups with distinctly different energies. The energies of those in the lowest energy group are close to that of the ground state (relative to the growth temperature) suggesting Fe^{3+} and Cu^{2+} to be disordered in YBFCO. Finally, we calculate exchange coupling constants for all the low energy configurations and show that the magnetic ordering resulting from these couplings is compatible with the experimentally-observed high-temperature magnetic ordering. However, they do not explain the existence of the experimentally observed low-temperature incommensurate magnetic structure.

MA 21.11 Wed 12:15 HSZ 04

Hybrid-functional study of the structural, magnetic and electronic properties of rare-earth nickelates — •Konstantin Z. Rushchanskii, Stefan Blügel, and Marjana Ležaić — Peter Grünberg Institut, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Rare-earth nickelates ($ReNiO_3$) are very promising functional perovskite crystalline materials, exhibiting metal-insulator (MI) transition, which can be continuously controlled by composition, bi-axial strain and(or) electric field. Unfortunately, conventional *ab initio* DFT+U results fail to reproduce their magnetic ground state as well as the effect of epitaxial strain on MI transition temperature. We present results of our comprehensive study of structural, magnetic and electronic properties of bulk $ReNiO_3$ (Re=Y, Gd, Eu, Sm, Nd and Pr) and strained $SmNiO_3$ films [1], performed with HSE06 functional. We show correlation between MI transition temperature and structural parameters of bulk and films, which nicely fits known experimental data. We also analyze the difference in the electronic structure obtained in DFT+U and with the hybrid functional and their influence on the resulting magnetic ordering in the ground state.

We acknowledge the support by Helmholtz Young Investigators Group Programme VH-NG-409, JSC and JARA-HPC.

[1] F.Y. Bruno, K.Z. Rushchanskii, S. Valencia, Y. Dumont, C. Carrétéro, E. Jacquet, R. Abrudan, S. Blügel, M. Ležaić, M. Bibes, and A. Barthélémy, Phys. Rev. B 88, 195108 (2013).

MA 21.12 Wed 12:30 HSZ 04

Magnetic properties of multiferroic $TbMnO_3$ — •Natalya Fedorova, Andrea Scaramucci, Claude Ederer, and Nicola Spaldin — ETH Zurich, Materials Theory, Wolfgang-Pauli-Strasse 27, CH-8093 Zurich, Switzerland

We use ab-initio calculations to investigate the magnetic properties of multiferroic $TbMnO_3$.

At low temperatures $TbMnO_3$ demonstrates an incommensurate spiral ordering of Mn spins which is accompanied by appearance of spontaneous electric polarization driven by applied magnetic field [1]. The establishment of such spin ordering is usually described within the framework of a Heisenberg model with competing nearest-neighbor and next-nearest-neighbor exchange interactions. However, our theoretical estimations of these interactions by ab-initio calculations demonstrate a clear deviation from Heisenberg model.

We consider first the coupling between magnetic and orbital orderings as a main source of non-Heisenberg behavior in $TbMnO_3$, but conclude that it does not explain the observed deviation. We find that higher order interactions (biquadratic and four-body spin couplings) should be taken into account for proper treatment of the magnetism in $TbMnO_3$.

[1] T. Kimura et al., Nature 426, 55-58 (2003)

MA 21.13 Wed 12:45 HSZ 04

Coupling of epitaxial strain and point-defect formation in perovskites — •Ulrich Aschauer, Philipp Baumli, and Nicola A. Spaldin — Materials Theory, ETH Zurich, Zürich, Switzerland

Using density functional theory calculations we recently established the existence of a strong coupling between epitaxial strain and the formation energy of oxygen vacancies in the model perovskite $CaMnO_3$ (Phys. Rev. B. 88, 054111, 2013). Here we investigate the generality of this concept for other oxides including metallic perovskites and also investigate the effect of strain on the formation of cation vacancies. We find that in general the response of the defect profile follows the behavior expected from chemical-expansion arguments, with tensile strain favoring oxygen vacancies and compressive strain favoring cation vacancies. We show, however, that material-specific details of the electronic structure can cause deviations from this trend under both tensile and compressive strain.

MA 22: Magnetization Dynamics I

Time: Wednesday 9:30–12:45 Location: HSZ 401

MA 22.1 Wed 9:30 HSZ 401

Pump-probe-experiments on individual atomic-scale superparamagnets — •Jan Hermenau, Andreas Sonntag, Johannes Friedlein, Stefan Krause, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Germany

In our experiments we investigate the fast thermal magnetization reversal of uniaxial atomic-scale magnets [1] using an all electrical pump-probe-scheme [2] implemented in a spin-polarized scanning tunneling microscopy setup.

During the pump-pulse, a temporal population asymmetry of the two magnetization directions is induced due to spin-transfer torque generated by a high spin-polarized tunnel current pulse. After a given time a small current pulse is used to probe the state of the magnet. From the thermal decay of the induced population asymmetry the intrinsic switching rate can be determined. In contrast to pump-probe experiments of Loth et al. the switching between two degenerate ground states can be investigated in absence of a magnetic field.

In our experiments we determine the switching rates of individual magnets at different temperatures. For temperature intervals of 22 K switching rates ranging over eight orders of magnitude are observed on a single magnet. The experiments reveal a deviation of the high switching rates from the predictions of the Néel-Brown-law. This is discussed in terms of multi-droplet nucleation und domain wall propagation.

[1] S. Krause *et al.*, Phys. Rev. Lett. **103**, 127202 (2009)
[2] S. Loth *et al.*, Nature Physics **6**, 340 (2010)

MA 22.2 Wed 9:45 HSZ 401

Ultrafast magnetic and structural dynamics in antiferromagnetic Europium-Telluride — •Christoph Trabant[1,2,3,6], Niko Pontius[1], Karsten Holldack[1], Enrico Schierle[1], Eugen Weschke[1], Torsten Kachel[1], Rolf Mitzner[1], Martin Beye[1], Gunther Springholz[4], Georgi Dakovski[5], Joshua J Turner[5], Stefan Möller[5], Tianhan Wang[5], Alex Gray[5], Markus Hantschmann[5,1], Hermann Dürr[5], Michael Minitti[5], W.S. Lee[5], Yi-De Chuang[5], Zuman Hussain[5], Z.X. Shen[5], Matias Bargheer[3], Daniel Schick[3], Alexander Föhlisch[1,3], and Christian Schüssler-Langeheine[1] — [1]Helmholtz-Zentrum Berlin — [2]II. Physikalisches Institut, Universität zu Köln — [3]Institut für Physik und Astronomie, Universität Potsdam — [4]Institute of Semiconductor and Solid State Physics, Johannes Kepler Universität Linz, Austria — [5]SLAC RSXS collaboration, USA — [6]present address: Institut für Experimentalphysik, FU Berlin

Laser-induced magnetic dynamics is generally assumed to occur much faster than structural effects induced by the same laser pulse. In order to verify that, we studied both dynamics in a metallic 4f AFM EuTe thin film. The dynamics were mapped using the strong resonant x-ray scattering signal of the AFM (001/2) superstructure and (001) structural reflection. Here we report that the loss of antiferromagnetic order precedes structural changes on ultrafast timescales followed by strain wave dominated dynamics. The optical pump xray probe measurements have been performed in one experiment at the SXR-beamline of LCLS. Supported by the BMBF through contract 05K10PK2.

MA 22.3 Wed 10:00 HSZ 401

The role of spin-lattice coupling in the ultrafast demagnetization of GdTb alloys — •Andrea Eschenlohr[1,2], Muhammad Sultan[1], Alexey Melnikov[3], Nicolas Bergeard[1], Jens Wieczorek[1], Torsten Kachel[2], Christian Stamm[2], and Uwe Bovensiepen[1] — [1]Universität Duisburg-Essen — [2]Helmholtz Zentrum Berlin — [3]Fritz-Haber-Institut der MPG, Berlin

$Gd_{1-x}Tb_x$ shows a two-step demagnetization after femtosecond (fs) laser excitation typical for rare earths [Wietstruk et al., PRL **106**, 127401 (2011)]. With fs time-resolved magneto-optical Kerr effect measurements we see that the time constant τ_1 of the first step is not correlated to x, while the rate $\gamma_2 = 1/\tau_2$ of the second step increases linearly with x. We therefore assign the first demagnetization step to the non-equilibrium dynamics of the $5d$ electrons, while the second step, which occurs under quasi-equilibrium conditions after electron-phonon equilibration, is dominated by the strong spin-lattice coupling of Tb given by the spin-orbit coupling of its $4f$ shell with $L = 3$. Complementary fs time-resolved x-ray magnetic circular dichroism measurements show a shared τ_2 of Gd and Tb in $Gd_{0.6}Tb_{0.4}$, but a transient difference in their magnitude of demagnetization. We attribute this to an increased spin-lattice coupling of Gd in $Gd_{0.6}Tb_{0.4}$, compared to pure Gd, via $5d$-$5d$ interatomic exchange coupling to neighboring Tb atoms. This coupling however has a limited efficiency, which explains the transient difference.

We acknowledge funding from BMBF Grant 05K10PG2 Femtospex and the DAAD-HEC Pakistan.

MA 22.4 Wed 10:15 HSZ 401

The Janus face of Gadolinium: different timescales for itinerant and localized magnetism — •Björn Frietsch[1,2], Robert Carley[1,2], Martin Teichmann[1,2], John Bowlan[1,2], and Martin Weinelt[1,2] — [1]Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin, Germany — [2]Max Born Institut, Max-Born-Straße 2a, 12489 Berlin, Germany

We present results of experiments from ultrafast laser-driven magnetization dynamics on the rare-earth local-moment ferromagnet Gadolinium. We use high order harmonic radiation to perform time- and angle-resolved photoemission spectroscopy [1].

With this technique it was possible to map the non-equilibrium band structure after excitation of the ferromagnet by a short infrared laser pulse and simultaneously follow the magnetic evolution of the 4f core level using magnetic linear dichroism.

The magnetization dynamics of the valence electrons and the 4f spins are strikingly different. While we observe subpicosecond demagnetization of the valence electronic system [2], the 4f core level exhibits a time constant of about 13ps.

[1] B. Frietsch, R. Carley, K. Döbrich, C. Gahl, M. Teichmann, O. Schwarzkopf, P. Wernet, and M. Weinelt Rev. Sci. Instrum. 84, 075106 (2013)
[2] R. Carley, K. Döbrich, B. Frietsch, C. Gahl, M. Teichmann, O. Schwarzkopf, P. Wernet, and M. Weinelt Phys. Rev. Lett. 109, 057401 (2012)

MA 22.5 Wed 10:30 HSZ 401

Switching dynamics of two-sublattice magnets — •Sönke Wienholdt[1], Denise Hinzke[1], Karel Carva[2,3], Peter Oppeneer[2], and Uli Nowak[1] — [1]University of Konstanz, Germany — [2]Uppsala University, Sweden — [3]Charles University in Prague, Czech Republic

It has been demonstrated recently that linearly polarized light can trigger a thermally driven switching in ferrimagnetic GdFeCo compounds [1,2] via a so called "ferromagnetic-like state", where the rare-earth

(RE) and transition metal sublattice magnetizations are aligned parallel on a ps time scale. The ultra-short time scale of the laser pulse and the high electron temperatures following the excitation lead to non-equilibrium processes where longitudinal magnetization dynamics becomes pronounced [2-4]. Recently, we have shown [5] that the thermally driven spin-switching of RE-based ferrimagnets can be well described on the basis of an orbital-resolved spin model, distinguishing electrons in d and f orbitals. In this talk we will show with atomistic spin model simulations that even after having reached the transient ferromagnetic-like state, the system does not necessarily switch. Recently this has also been observed experimentally with element specific measurements on TbFeCo [6]. We acknowledge funding by the European Comission via the Collaborative Project FEMTOSPIN.

[1] I. Radu et al., Nature 472, 205 (2011). [2] T. A. Ostler et al., Nat. Commun. 3, 666 (2012). [3] N. Kazantseva et al., Europhys. Lett. 81, 27004 (2008). [4] J. H. Mentink et al., Phys. Rev. Lett. 108, 057202 (2012). [5] S. Wienholdt et al., Phys. Rev. B 88, 020406(R) (2013). [6] A. R. Khorsand et al., Phys. Rev. Lett. 110, 107205 (2013).

MA 22.6 Wed 10:45 HSZ 401

Ultrafast Spin dynamics in multicenter Nickel complexes — •Debapriya Chaudhuri, Georgios Lefkidis, and Wolfgang Hübner — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67653 Kaiserslautern, Germany

We present ultrafast logic elements in molecular systems with active magnetic centers using *ab initio* theory and show the possibility of coherent spin manipulation [1]. The processes are investigated in Ni_n (n = 2,3,4) clusters where spin localization, spin-flip, spin-transferability and demagnetization are discussed with respect to their geometries.

We investigate laser-induced, spin-dynamics scenarios on Ni_2 at various interatomic distances. High-fidelity spin-switching is possible within 500 fs with the Λ-process. At each bond length the dimer responds to a specially optimized pulse. Strong correlations are observed and new rules-of-thumb are derived. In case the Λ-process fails, switching is achieved through the M-process that includes more intermediate states with higher occupations. Ni_4 [2] is a good cluster of interest due to its flexibility in achieving local spin-flips and spin-transfers between magnetic centers which occur within 350 fs. Inclusion of higher multiplicities such as quintets in the excited states provides an insight to the phenomena such as reversible global spin-switch and irreversible demagnetization scenarios within 350-400 fs.

[1] G. Lefkidis, G. P.Zhang, and W. Hübner, Phys. Rev. Lett. **103**, 217401 (2009).
[2] M. H. Ghatee, and Leila Pakdel, Int. J. Quantum Chem. **113**, 1549 (2013).

15 min. break

MA 22.7 Wed 11:15 HSZ 401

Equilibration of Electron Temperatures and Chemical Potentials during Ultrafast Magnetization Dynamics — •Benedikt Y. Mueller and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

Exciting a ferromagnetic nickel film with an ultrashort laser pulse leads to a quenching of the magnetization on a subpicosecond timescale [1]. Since this discovery, several models for the microscopic mechanism have been proposed, for instance, spin-flip scattering [2,3,4] and superdiffusive transport [5]. Today it seems that both processes contribute to the demagnetization, depending on the sample properties. Easy-to-handle models are essential to predict dynamic properties of systems with increasing complexity. Exploiting insights from our analysis of the spin-resolved Boltzmann equation [2,4] we set up a model governed by the equilibration of temperatures and chemical potentials of spin-up and spin-down electrons. This opens the possibility to describe transport effects in parallel with spin-flip processes and allows for analytical predictions of the demagnetization dynamics.

[1] Beaurepaire et al., PRL 76, 4250 (1996)
[2] Mueller et al., PRL 111, 167204 (2013)
[3] Koopmans et al., NMAT 9, 259 (2010)
[4] Essert et al., PRB 84, 224405 (2011)
[5] Battiato et al., PRL 105, 027203 (2010)

MA 22.8 Wed 11:30 HSZ 401

Ultrafast demagnetisation dynamics in Cu-doped Permalloy — •Sadashivaiah Sakshath[1], Oliver Schmitt[1], Daniel Steil[1], Moritz Barkowski[1], Sabine Alebrand[1], Ute Bierbrauer[1], Emrah Turgut[2], Patrik Grychtol[2], Justin Shaw[3], Roman Adam[4], Chan La-O-Vorakiat[2], Hans T. Nembach[3], Claus M. Schneider[4], Margaret M. Murnane[2], Henry C. Kapteyn[2], Thomas J. Silva[3], Stefan Mathias[1], and Martin Aeschlimann[1] — [1]TU Kaiserslautern, Germany — [2]JILA, University of Colorado, USA — [3]NIST, Boulder, USA — [4]Forschungszentrum Jülich, Germany

Permalloy doped with Copper presents itself as an interesting system for investigations of ultrafast demagnetisation dynamics as the exchange interaction is tuned [1]. Here, we perform fluence dependent TR-MOKE measurements for different Copper concentrations. In pure Permalloy, where exchange coupling is strong, and the Curie temperature is high, the demagnetisation time constant (τ_m) increases monotonously as the magnetization is quenched. These dynamics gradually change with increasing copper concentration. First, the total demagnetization times become slower, and second we observe a drastic reduction of τ_m at high quenching values, similar to the predictions of the M3TM model [2]. The influence of varying exchange coupling on the measured ultrafast demagnetization rates is discussed.

[1] S. Mathias *et al.*, PNAS **109**, 4792 (2012)
[2] B. Koopmans *et al.*, Nature Materials **9**, 259 (2010)

MA 22.9 Wed 11:45 HSZ 401

Thickness dependent ultrafast magnetization dynamics in Co/Cu(100) films — •Jens Wieczorek, Nicolas Bergeard, Andrea Eschenlohr, Alexander Tarasevitch, Boris Weidtmann, Andreas Duvenbeck, and Uwe Bovensiepen — Universität Duisburg-Essen, Fakultät für Physik, Germany

To disentangle the local and non-local contributions in femtosecond laser induced demagnetization [1,2,3], we measure the variation of the magneto optical Kerr rotation and ellipticity of Co/Cu(100) films at thicknesses 2 nm $< d <$ 20 nm. We find an increasing quenching of the magnetization and a shift of the time delay of maximum demagnetization to longer delay times with increasing film thickness. Both effects result from a competition between light absorption in cobalt and energy transport to copper. Due to the high thermal conductivity copper acts in our investigated sample as an energy sink. For thicker films the transport to the substrate is decreased due to lower heat conductivity in cobalt and the energy remains longer in Co. This results in a higher excess electron energy density and a reduced cooling, so that the sample can demagnetize longer and stronger. This behavior is also seen in three temperature model [3] simulations, which include different heat conductivity in Co and the Cu substrate. This shows the importance of energy transport to a conducting substrate in magnetization dynamics. We acknowledge support by the DFG through SFB616 and the Mercator Research Center Ruhr through Projekt 2011-0003. [1]Battiato et al., PRL **105**, 027203 (2010); [2]Melnikov et al., PRL **107**, 076601 (2011); [3]Koopmans et al., Nat. Mat. **9**, 259 (2010).

MA 22.10 Wed 12:00 HSZ 401

Spin transfer in Au/Fe/MgO(001) structures by optically excited hot carrier transport — •Alexandr Alekhin[1], Damian Bürstel[2], Tim O. Wehling[3], Detlef Diesing[2], Ivan Rungger[4], Maria Stamenova[4], Stefano Sanvito[4], Uwe Bovensiepen[5], and Alexey Melnikov[1] — [1]Fritz-Haber-Institut der MPG, Abt. Phys. Chemie — [2]Universität Duisburg-Essen, Institut für Phys. Chemie — [3]Universität Bremen, Theor. Phys. Institut — [4]Trinity College Dublin, School of Physics and CRANN — [5]Universität Duisburg-Essen, Fakultät für Physik

Spin transfer induced by ultrashort laser pulses is of great importance in light of recent advances in spintronics and attempts to control magnetization on femtosecond (fs) time scales. Using 14 fs laser pulses in pump-probe experiments performed on the epitaxial Au/Fe/MgO(001) structures, we pump the Fe film to excite and inject spin-polarized hot carriers (HC) into the Au layer and probe the Au side of the samples to monitor transient bulk spin polarization (SP) by the magneto-optical Kerr effect (MOKE) and transient SP at the Au surface by the magneto-induced second harmonic generation (mSHG). Analyze of the transient MOKE and mSHG signals as functions of Au thickness let us study evolution of the HC packet and the spin current pulse and evaluate that the velocity of the ballistic fraction of the HC packet equals to 1.19 nm/fs which is close to the ballistic velocity of minority electrons in Au. Varying Fe thickness, we demonstrate the possibility to manipulate the ballistic fraction of the HC packet. DFG (ME 3570/1, Sfb 616) and EU 7-th framework program (CRONOS) are acknowledged.

MA 22.11 Wed 12:15 HSZ 401

Time-resolved MOKE in Au/Fe/MgO(001) structures: hot carrier transport and response of transiently magnetized

Au — Alexandr Alekhin[1], Damian Bürstel[2], Detlef Diesing[2], Tim O. Wehling[3], Ivan Rungger[4], Maria Stamenova[4], Stefano Sanvito[4], Markus Münzenberg[5], Uwe Bovensiepen[6], and •Alexey Melnikov[1] — [1]Fritz-Haber-Institut der MPG, Abt. Phys. Chemie — [2]Universität Duisburg-Essen, Institut für Phys. Chemie — [3]Universität Bremen, Theor. Phys. Institut — [4]Trinity College Dublin, School of Physics and CRANN — [5]Universität Göttingen, I. Phys. Institut — [6]Universität Duisburg-Essen, Fakultät für Physik

Ultrafast spin dynamics (SD) is the key for development of faster data storage and spintronics devices. In metals with highly mobile hot carriers (HC) SD is essentially non-local and determined by the transport of spin-polarized HC. Therefore we consider the effect of HC transport being superimposed onto SD originating from the spin-lattice interaction. We investigate this non-locality of optically excited SD in Au/Fe/MgO(001) structures observing magneto-optical Kerr effect (MOKE) with 20 fs time resolution. Exciting the Fe layer and probing either the Fe or Au sides of the sample, we demonstrate the crucial role of spin-polarized HC transport in ultrafast SD and reveal a sizable contribution of transiently magnetized Au into the MOKE signal. Finally, we propose a technique for the definition of magneto-optical constants of non-magnetic materials based on spin polarized HC transport and estimate the magneto-optical constant of Au. DFG (ME 3570/1, Sfb 616) and EU 7-th framework program (CRONOS) are acknowledged.

MA 22.12 Wed 12:30 HSZ 401

Spin-resolved photoelectron spectroscopy using femtosecond extreme ultraviolet light pulses — •Moritz Plötzing, Roman Adam, Christian Weier, Lukasz Plucinski, and Claus M. Schneider — Peter Grünberg Institut (PGI-6), Research Center Jülich, 52425 Jülich, Germany

The ongoing discussion about the physical mechanism responsible for femtosecond magnetization dynamics raise the demand for new experimental techniques capable of accessing fundamental properties of ferromagnetic materials, *e.g.* by investigating the ultrafast evolution of the spin-resolved band structure. Our work focusses on a combination of highly efficient spin detection in a photoemission spectroscopy (PES) experiment and a femtosecond laser-driven extreme ultraviolet (XUV) light source. Using the ultrashort XUV pulses, we measured spin-resolved PES spectra of thin Co films grown *in-situ* on Cu(100). By a comparison of these results with spectra obtained using a continuous-wave He discharge lamp, we identified important differences due to the excitation with the XUV source. Furthermore, we found that the spectra measured using the pulsed XUV source allow the extraction of important magnetic properties including the exchange splitting. The necessary acquisition times are fully suited for time-resolved experiments employing a pump-probe scheme.

MA 23: Micro- and Nanostructured Magnetic Materials

Time: Wednesday 9:30–12:15 Location: HSZ 403

MA 23.1 Wed 9:30 HSZ 403

A new template for in-situ characterization of electrodeposited nanowires using a sub-100 nm nanochannel array presented at the example of electron magnon scattering in iron nanowires — •Philip Sergelius, Josep M. Montero Moreno, Wehid Rahimi, Martin Waleczek, Robert Zierold, Detlef Görlitz, and Kornelius Nielsch — Institute of Applied Physics: University of Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany

We present a new generation of templates for nanowire growth and their in-situ characterization. Using Interference Lithography, Reactive Ion Etching and ALD, a flexible template consisting of cm-long parallel nanochannels with rectangular cross section and other dimensions as small as 40 nm can be created. In an illustration system, pulsed electrodeposition is carried out creating square shaped Fe nanowires (80x80x20000 nm). By design, the grown wires are in contact with an electrode system on both sides directly after the deposition. No further processing steps are required for electrical characterization. The surrounding oxide template remains intact during measurement, providing protection against breaking and oxidation. The developed chip enables us to conduct high field R(T,B)-measurements on electroplated Fe nanowires for the first time. We report values for the magnon mass renormalization which are in good agreement with literature.

Using the presented approach, we believe that electrical characterization of nanowires will be a lot easier in the future. Additionally it opens up the possibility to create stable transversal magnetic anisotropy in multisegmented magnetic nanowires.

MA 23.2 Wed 9:45 HSZ 403

Ab initio study of selected fibred configurations in Fe-Pd and Fe-Pt systems — •Martin Zouhar[1] and Mojmír Šob[1,2,3] — [1]Central European Institute of Technology, CEITEC MU, Brno, Czech Republic — [2]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic — [3]Department of Chemistry, Faculty of Science, Masaryk University, Brno, Czech Republic

We perform a first-principles theoretical study of fibred magnetic configurations in ordered Fe-Pd and Fe-Pt face-centered cubic based intermetallics with low Fe content, namely FeX_3, FeX_7 and FeX_{15} (X = Pd or Pt), that contain iron fibres in the platinum or palladium matrix. The pseudopotential code VASP (Vienna Ab initio Simulation Package) is used to determine the equilibrium lattice parameters of the structures and corresponding total energies. Nonmagnetic, ferromagnetic and selected antiferromagnetic arrangements are considered and the configurations with the lowest energies are discussed in detail, including concentration dependence of both equilibrium volumes and magnetic moments.

MA 23.3 Wed 10:00 HSZ 403

Magnetic order triggered by hydrogenation of Li-doped ZnO microwires — •Israel Lorite[1], Benjamin Straueb[2], Parmod Kumar[1], Carlos Zandalazini[2], Hendrik Ohldag[3], Silvia de Heluani[2], and Pablo Esquinazi[1] — [1]Division of Superconductivity and Magnetism, University of Leipzig, Leipzig, Germany — [2]Laboratorio de Fisica de Solido, Universidad de Tucuman, Tucuman, Argentina — [3]SLAC National Accelerator Laboratory, Menlo Park, Stanford University, CA, USA

Cation and oxygen vacancies, as well as hydrogen can play an important role in the magnetic order observed in nominally non-magnetic oxides like ZnO, a phenomenon called nowadays as defect-induced magnetism (DIM). In this work we have produced microwires of ZnO, pure and doped with 1...7 atom.% Li. The magnetic characterization of the wires has been realized using magnetoresistance, superconducting quantum interferometer device (SQUID), photoconductivity and x-ray magnetic circular dichroism (XMCD). Photoluminescence spectroscopy was performed to elucidate the incidence of defects. Our results indicate that hydrogenation of pure ZnO microwires triggers magnetic order at temperatures below 100K. Room temperature magnetic order is observed after hydrogenation of Li-doped ZnO with a Li concentration above 1%, in agreement with the expected minimum distance between localized defects necessary to trigger magnetic order. Hydrogenation is a simpler and more effective way to trigger DIM in nominally non-magnetic oxides microstructures, paving the way for possible future applications of this phenomenon.

MA 23.4 Wed 10:15 HSZ 403

Electric field effects on magnetic properties of transition-metal impurities on monolayer graphene — •Karla Türschmann[1], Jesús Dorantes-Dávila[2], and Gustavo M. Pastor[1] — [1]Institut für theoretische Physik, Universität Kassel, Kassel, Germany — [2]Instituto de Física, Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico

The manipulation of the magnetic properties of nanoscale materials with external electric fields is of considerable interest both as fundamental research subject and in view of developing nanoscale magneto-electronic devices. Two-dimensional monolayer graphene (MLG) with its unique electronic properties is one of the most promising materials for future applications. Therefore, using MLG as a substrate for magnetic 3d transition metal (TM) nanoclusters should offer new opportunities in spintronics. This contribution presents the results of *ab-initio* density-functional theory of the magnetic properties of 3d TM adatoms and dimers on MLG as a function of applied external electric field E. Special attention is paid to field-induced changes of the magnetic order, the magnetic anisotropy energy and of the orientation of magnetization. For instance, in the case of Co dimers on MLG the electric field induces a transition from FM to AFM ordering as well as a change of the direction of the easy axis. Trends for other TMs are also discussed.

MA 23.5 Wed 10:30 HSZ 403

Scanning-Hall-Probe-Microscopy on perpendicular stray-fields of Head-To-Head-Exchange-Bias-Layers — •Arno Ehresmann[1], Stefan Pofahl[2], Florian Ahrend[1] und Norbert Zingsem[1] — [1]Universität Kassel, Experimentalphysik 4, D-34419 Kassel — [2]IFW-Dresden, Leibniz-Institut für Festkörper- und Werkstoffforschung

Exchange-bias-multilayer-systems with CoFe and IrMn as main components were patterned by ion-bombardment in 5mu-head-to-head-domains. On those systems scanning-hall-probe-microscopy was carried out, to measure the height dependent z-component of the stray field arising from the domainwalls. Comparison with existing theory on domain- and fieldstructure showed qualitatively good agreement, but also quantitative hints that an adjustment of that theory might be necessary.

15 min. break

MA 23.6 Wed 11:00 HSZ 403

Switching modes in a self-assembled antidot array — Felix Haering[1], •Ulf Wiedwald[1,2], Steffen Nothelfer[1], Berndt Koslowski[1], Paul Ziemann[1], Lorenz Lechner[3], Andreas Wallucks[4], Kristof Lebecki[4], Ulrich Nowak[4], Joachim Gräfe[5], Eberhard Goering[5], and Gisela Schütz[5] — [1]Institute of Solid State Physics, Ulm University, 89069 Ulm — [2]Faculty of Physics, University of Duisburg-Essen, 47057 Duisburg — [3]Electron Microscopy Group of Materials Science, Ulm University, 89069 Ulm — [4]Department of Physics, University of Konstanz, 78457 Konstanz — [5]Max Planck Institute for Intelligent Systems, 70569 Stuttgart

We study the magnetic reversal in a self-assembled, hexagonally ordered Fe antidot array (period 200 nm, antidot diameter 100 nm) which was prepared by nanosphere lithography [1]. Direction-dependent information in such a self-assembled sample is obtained by measuring the anisotropic magnetoresistance (AMR) through constrictions processed by focused ion beam milling in nearest neighbor and next nearest neighbor directions [2]. We show that such an originally integral method can be used to investigate the strong 6-fold in-plane anisotropy introduced by the antidot lattice. In-field magnetic force microscopy, Kerr microscopy and micromagnetic simulations are employed to correlate the microscopic switching to features in the AMR signal. We thank the Baden-Württemberg Stiftung for financial support. [1] F. Haering et al., Nanotechnology 24, 055305 (2013). [2] F. Haering et al., Nanotechnology 24, 465709 (2013).

MA 23.7 Wed 11:15 HSZ 403

Magnetisation Reversal of In-Plane and Out-of-Plane Magnetised Antidot Lattices — •Joachim Gräfe[1], Felix Häring[2], Ulf Wiedwald[4], Paul Ziemann[2], Kristof Lebecki[3], 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 — [4]Faculty of Physics, Duisburg, Germany

Antidot lattices allow tailoring of important magnetic properties like coercivity and magnetic anisotropy. Angular and spatially resolved MOKE measurements as well as magnetic x-ray microscopy (MAXYMUS) were conducted in order to gain insight into magnetisation properties of in-plane (Fe) and out-of-plane (GdFe) antidot systems. These studies were complemented by first order reversal curve (FORC) measurements and micromagnetic simulations. The magnetisation behaviour of in-plane antidot lattices is dominated by domain wall pinning in the narrow bridges between the holes. Domain walls run along the antidot rows and sudden domain wall motion occurs for a critical field applied along the nearest neighbour direction. For the next nearest neighbour direction the magnetisation reversal follows a rotational mechanism via an intermediate easy axis. Out-of-plane systems do not suffer from additional stray field losses at the antidots as inplane systems do. Nevertheless, we found a significant influence on the coercivity and the shape of the hysteresis loops of thin films with perpendicular magnetic anisotropy and antidot structuring. FORC measurements reveal an interplay between exchange and dipole interactions.

MA 23.8 Wed 11:30 HSZ 403

Thermal excitations of artificial spin ice in square-lattice dipolar arrays — •Danny Thonig[1,2], Stephan Reissaus[2], and Jürgen Henk[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

Frustration in magnetic systems is a topic of particular interest in condensed matter physics. Recent experiments on artificial two-dimensional spin ice reveal thermal magnetic excitations, reminiscent of Dirac strings and magnetic monopoles [1]. We report on a theoretical investigation of artificial spin ice in square-lattice dipolar arrays, using a geometry adopted from recent experiments [2], applying conventional and kinetic Monte Carlo methods.

The number of thermal string excitations with quasi-monopoles ± 4 can be drastically increased by a vertical displacement, a change of the island's thickness and variation of the magnetization of rows and columns. The increase is especially large at low temperatures. Addressing the thermal stability of these excitations, we provide time scales for their experimental observation. Furthermore, the excitations can be pinned by defects, which allows to control position and length of the string excitations.

[1] E. Mengotti *et al.*, Nature Phys. **7** (2011) 68-74
[2] A. Farhan *et al.*, Nature Phys. **9** (2013) 375.

MA 23.9 Wed 11:45 HSZ 403

Transport Measurements on Individual Ferromagnetic MnAs Nanocluster Arrangements — •Martin Fischer[1], Matthias T. Elm[1], Shinya Sakita[2], Shinjiro Hara[2], 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

The ongoing progress in the development of nano-magnetoelectronic devices is strongly connected to the exploration of novel, nanostructured magnetic materials. This contribution reports on transport measurements on ferromagnetic manganese arsenide nanoclusters and nanocluster arrangements grown by Selective-Area Metal-Organic Vapor Phase Epitaxy (SA-MOVPE), which offer a wide choice of pattern designs combined with a convenient processability.

The results of the transport measurements, even in zero magnetic field, show jump-like changes of the resistance. These changes are caused by magnetoelectric effects in the nanoclusters. The relative angle between the magnetization directions of neighbored domains determines the resistance of their boundary. Furthermore, domain wall dynamic effects occur depending on the sample temperature, which results in changes of the resistance. The impact of external influences, such as an external magnetic field or the sample temperature on the transport characteristics will be discussed. In addition, possible ways towards a theoretical description of the experimental findings will be discussed.

MA 23.10 Wed 12:00 HSZ 403

Field assisted sintering of nanostructured iron oxide composites — •Kerstin Witte, Wiktor Bodnar, and Eberhard Burkel — Institute of Physics, University of Rostock, August-Bebel-Str. 55, 18055 Rostock, Germany

The behaviour of magnetic materials depends strongly on their domain structure. For nanoparticles and thin films a broad range of interesting effects like superparamagnetism or giant magnetoresistance have been observed, while the behaviour of nanostructured bulk materials is still widely unknown. Various physical properties of bulk materials and composites can be significantly affected by the careful control of both composition and nanoscale grain structure. The rather novel field assisted sintering technique (FAST) is a promising tool for the consolidation and synthesis of such nanostructured bulk materials. During FAST a pulsed direct electric current and mechanical load are applied on precursor powder placed in a graphite die, leading to rapid heating of the densified powder. Advantages of FAST are short process times and the possibility of keeping nanostructured grains. To study changes in the behaviour of magnetic materials, soft magnetic iron oxides are an ideal system due to their metastability, as well as the large single domain size of magnetite and maghemite. In this study a stoichiometric mixture of hematite and iron was processed by FAST. The composition and other various physical properties of the obtained composites were determined using high energy X-ray diffraction, scanning electron microscopy and Mößbauer spectroscopy.

MA 24: Focus Session: Chiral domain walls in ultrathin films

Organizer: Stefan Blügel (Forschungszentrum Jülich)

During the past years we witnessed a breakthrough in the observation and application of chiral domain walls to spintronics. In chiral domain walls the magnetization rotates from one domain to the next with a preferred handedness. They are a result of the Dzyaloshinskii-Moriya interaction originating from spin-orbit interaction in combination with the lack of inversion symmetry of the atomic structure e.g. due to the presence of interfaces. The presence of Néel-type chiral domain walls in thin perpendicularly magnetized ferromagnetic films has been pointed out by theory and they were observed first by spin-polarized scanning tunneling microscopy (SP-STM). Recent low-energy electron microscopy (LEEM) experiments show that the formation of this novel type of wall may be a rather general phenomenon in thin films with structure-asymmetry and that the chirality of the domain wall can be engineered using different materials combinations and stackings. It was demonstrated that the Dzyaloshinskii-Moriya interaction stabilizes the domain wall during motion and the current-induced wall motion is very efficient for this type of wall. The origin of the torque the current exerts on the magnetization when driving the domain wall motion, i.e. the degree of spin-transfer torque (STT) and spin-orbit torque (SOT) is currently a matter of debate. Chiral domain walls provide unprecedented opportunities for the development of spintronic devices and in the focus session we try to illuminate different aspects including their observation, the dynamics and applications.

Time: Wednesday 9:30–12:15 Location: BEY 118

Topical Talk MA 24.1 Wed 9:30 BEY 118

On the rediscovery of the Dzyaloshinskii-Moriya interaction—A review — •Matthias Bode — Physikalisches Institut, Experimentelle PhysikUniversität Würzburg II, , Am Hubland, D-97074 Würzburg, Germany

Even though it had already been theoretically predicted in 1960 [1,2] that the spin-orbit–driven Dzyaloshinskii–Moriya interaction (DMI) may lead to chiral spin structures in magnetic systems with broken inversion symmetry, this term was largely ignored for decades. This is particularly astonishing as experimental progress allowed the preparation of increasingly subtle magnetic structures which feature surfaces and interfaces or even—as in the case of magnetic nanostructures—exclusively consist of surfaces and interfaces. Obviously, in all these sample geometries inversion symmetry is broken and a sufficiently strong spin-orbit coupling should lead to chiral magnetism [3]. In this talk I will review why the importance of the DMI interaction in thin film and nano magnetism was overlooked for so long, and how scientific persistence [4] eventually led to irrefutable evidence that it not only exists [5] but in some (if not many) cases strongly influences [6,7] or even dominates magnetic order.

[1] I.E. Dzialoshinskii, Sov. Phys. JETP **5**, 1259 (1957).
[2] T. Moriya, Phys. Rev. **120**, 91 (1960).
[3] A. Bogdanov and A. Hubert, J. Magn. Magn. Mat. **138**, 255 (1994).
[4] A. Bogdanov and U. Rößler, Phys. Rev. Lett. **87**, 037203 (2001).
[5] M. Bode *et al.*, Nature **447**, 190 (2007).
[6] M. Heide *et al.*, Phys. Rev. B **78**, 140403 (2008).
[7] S. Meckler *et al.*, Phys. Rev. Lett. **103**, 157201 (2009).

Topical Talk MA 24.2 Wed 10:00 BEY 118

Chiral Magnetic Domain Wall Structure in Epitaxial Multilayers — •Yizheng Wu[1], Gong Chen[2,1], Jie Zhu[1], Alpha T. N'Diaye[2], Tianping Ma[1], HeeYoung Kwon[3], Changyeon Won[3], and Andreas. K. Schmid[2] — [1]Physics Department,Fudan University, Shanghai, China — [2]NCEM, LBNL, Berkeley, California, USA — [3]Department of Physics, Kyung Hee University, Seoul , Korea

In ultrathin film, the inversion symmetry broken at interface will induce Dzyaloshinskii-Moriya interaction (DMI). In this talk, we will show that the DMI at interface will induce the chiral Néel type domain wall in perpendicularly magnetized films. The spin structure in magnetic domain wall was identified in real-space at room temperature by spin-polarized low energy electron microscopy (SPLEEM). The chiral Néel-type domain wall was identified in the magnetic stripe domain phase in Fe/Ni/Cu(001), and the chirality can switch from the right-hand cycloid in Fe/Ni/Cu(001) to the left-hand cycloid in Ni/Fe/Cu(001), which indicates that the chirality is caused by the DMI mainly located at the Fe/Ni interface [1]. The chiral domain wall structure can also be observed in [Co/Ni]n multilayer grown on Pt(111) and Ir(111)[2]. by inserting an Ir layer between the Co/Ni stack and the Pt substrate and varying the thickness of the Ir layer, we prove that domain wall chirality together with the sign and strength of the DMI can be tuned through the interface engineering, which may enable more possibility for designing of new spintronics devices.

[1] G. Chen, et al., Phys. Rev. Lett. 110, 177204 (2013) [2] G. Chen, et al., Nature Communication, 4,2671(2013)

15 min. break

Topical Talk MA 24.3 Wed 10:45 BEY 118

'Dzyaloshinskii domain walls' in ultrathin magnetic films — •André Thiaville[1], Stanislas Rohart[1], Emilie Jué[2], Olivier Boulle[2], Vincent Cros[3], Albert Fert[3], Stefania Pizzini[4], and Jan Vogel[4] — [1]Lab. Phys. Solides, CNRS, Univ. Paris-Sud, 91405 Orsay, France — [2]SPINTEC, INAC, CEA-CNRS-UJF-INPG, 38054 Grenoble, France — [3]UMP CNRS-Thales & Univ. Paris-Sud, 91767 Palaiseau, France — [4]Institut Néel, CNRS-UJF, 38042 Grenoble, France

In ultrathin magnetic films with perpendicular anisotropy and vertical structural inversion asymmetry, we have recently proposed [1] that the domain walls are chiral Néel walls with a peculiar dynamics. This results from a Dzyaloshinskii-Moriya interaction (DMI) of the interfacial type, predicted by A. Fert long ago and observed on monolayers by SP-STM [2]. Several recent experimental observations of the dynamics of domain walls in such samples, under fields and current, are in agreement with this picture, with the effect of current incorporated by the spin Hall effect in an adjacent layer [3].

After recalling the main characteristics of these Dzyaloshinskii domain walls, I will describe additional features that occur at large values of the DMI (but still in the region where an isolated domain is stable), namely the tilt of such walls in nanostrip-shaped samples. This affects the statics and dynamics of these walls [4].

[1] A. Thiaville et al., EPL 100, 57002 (2012) [2] P. Ferriani et al., PRL 101, 027201 (2008) [3] S. Emori, et al., Nature Mater. 12, 611 (2013) [4] O. Boulle et al., PRL 111, 217203 (2013)

Topical Talk MA 24.4 Wed 11:15 BEY 118

Current-driven dynamics of chiral ferromagentic domain walls — •Geoffrey Beach — MIT Dept. of Mater. Sci. and Eng., Cambridge, MA, USA

In most ferromagnets the magnetization rotates from one domain to the next with no preferred handedness. However, broken inversion symmetry can lift the chiral degeneracy, leading to topologically rich spin textures such as spin-spirals and skyrmions via the Dzyaloshinskii-Moriya interaction (DMI) [1-3]. Here we show that in ultrathin metallic ferromagnets sandwiched between a heavy metal and an oxide, the DMI stabilizes chiral domain walls (DWs) whose spin texture enables extremely efficient current-driven motion [4-6]. We show that spin torque from the spin Hall effect drives DWs in opposite directions in Pt/CoFe/MgO and Ta/CoFe/MgO, which can be explained only if the DWs assume a Néel configuration with left-handed chirality. We directly confirm the DW chirality and rigidity by examining current-driven DW dynamics with magnetic fields applied perpendicular and parallel to the spin spiral [4,6]. This work identifies the origin of efficient current-driven domain wall motion in heavy metal/ferromagnet bilayers, and highlights a new path towards interfacial design of spintronic devices. In collaboration with S. Emori, U. Bauer, and E. Martinez.

[1] M. Bode, et al., Nature 447, 190 (2007). [2] S. Heinze, et al., Nature Physics 7, 713 (2011). [3] A. Thiaville, et al., Europhys. Lett. 100, 57002 (2012). [4] S. Emori, et al., Nature Mater. 12, 611 (2013). [5] E. Martinez, et al., APL 103, 072406 (2013). [6] S. Emori, et al., arXiv:1308.1432 (2013).

Topical Talk MA 24.5 Wed 11:45 BEY 118

Phenomenology of current-induced spin-orbit torques — •Kjetil M. D. Hals — The Niels Bohr International Academy, Niels Bohr Institute, 2100 Copenhagen, Denmark

Recent developments have shown that currents can cause magnetization torques via relativistic, intrinsic spin-orbit coupling, often referred to as spin-orbit torques (SOTs). A detailed understanding of the SOTs requires improved theoretical models that exceed the present phenomenological framework used to model current-induced magnetization dynamics. In this talk, I present a novel phenomenology of current-induced torques that is valid for any strength of intrinsic spin-orbit coupling [1]. In Pt|Co|AlOx, I demonstrate that the domain walls move in response to a novel relativistic dissipative torque that is dependent on the domain wall structure and that can be controlled via the Dzyaloshinskii-Moriya interaction. Unlike the non-relativistic spin-transfer torque, the new torque can, together with the spin-Hall effect in the Pt-layer, move domain walls by means of electric currents parallel to the walls.

[1] K. M. D. Hals and A. Brataas, Phys. Rev. B 88, 085423 (2013).

MA 25: Graphene: Transport (with DY/DS/O/TT)

Time: Wednesday 9:30–12:15 Location: POT 051

MA 25.1 Wed 9:30 POT 051

Ratchet effects in graphene with a lateral potential — •Josef Kamann[1], Leonid Golub[2], Matthias König[1], Jonathan Eroms[1], Felix Fromm[3], Thomas Seyller[3], Dieter Weiss[1], and Sergey Ganichev[1] — [1]University of Regensburg, Germany — [2]Ioffe Physical-Technical Institute of the RAS, St. Petersburg, Russia — [3]Technical University of Chemnitz, Germany

We report on the observation of terahertz radiation induced ratchet effects in graphene with a lateral periodic potential. These effects generate a dc electric current from an ac electric field. To probe ratchet effects, a metal grating has been deposited on top of epitaxially grown graphene. This lattice contains periodically deposited stripes with different widths and spaces and, therefore, has no inversion symmetry.

We demonstrate that the ratchet effect is generated only in the modulated area and does not arise in unpatterned graphene. This proves the symmetry breaking induced by the asymmetric lateral potential. Additional effects like edge currents or the circular ac Hall effect are excluded by the geometry of the samples and by illumination under normal incidence. The ratchet signal is studied with respect to the polarization and the wavelength of the radiation. We show that the ratchet effect is sensitive to both linear and circular polarization and conducted calculations for different elastic-scattering processes to compare them to our experimental findings.

MA 25.2 Wed 9:45 POT 051

Magnetic quantum ratchet effect in graphene — •Christoph Drexler[1], Sergey Tarasenko[2], Peter Olbrich[1], Johannes Karch[1], Marion Hirmer[1], Florian Müller[1], Martin Gmitra[1], Jaroslav Fabian[1], Rositza Yakimova[3], Samuel Lara-Avila[4], Sergey Kubatkin[4], Minjie Wang[5], Junichiro Kono[5], and Sergey Ganichev[5] — [1]THz Center, University of Regensburg, Germany — [2]Ioffe Physical-Technical Institute, St. Petersburg, Russia — [3]Linköping University, Sweden — [4]Chalmers University, Göteborg, Sweden — [5]Rice University, Houston, USA

We report on the experimental observation of the magnetic quantum ratchet effect in epitaxial- and CVD- grown graphene layers excited by pulsed terahertz (THz) - laser radiation [1]. Our experimental findings can be well understood in terms of asymmetric carrier scattering in graphene in presence of an in-plane magnetic field yielding strong structure inversion asymmetry (SIA) in graphene. The SIA stems from the fact that graphene is deposited on a substrate and/or is sensitive to chemical bonding of adatoms on the surface. Considering hydrogen atoms on top of carbon we calculated the magnitude of the photocurrent being in good agreement with the data obtained from the experiments. The amplitudes of the current differ significantly for the used material systems whereas its sign can be influenced by the post-groth treatment of the samples. The ratchet current can be calibrated to measure the strength of the SIA, which plays an important role in graphene ferromagnetism and spintronics.

[1] C. Drexler et al, Nat. Nano. 8 104-107, 2013.

MA 25.3 Wed 10:00 POT 051

Spin transport in arrays of graphene nanoribbons — Matthias Berl, Bastian Birkner, Andreas Sandner, Silvia Minke, Dieter Weiss, and •Jonathan Eroms — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany

We performed non-local spin valve and Hanle measurements in arrays of graphene nanoribbons in both single and bilayer graphene. Nanoribbons were patterned by electron beam lithography and oxygen-based reactive ion etching. By fabricating several sets of electrodes, we can compare spin transport data in bulk and nanoribbons on the same graphene flake. Due to band-gap opening in the nanoribbons at low temperatures, spin transport measurements were only possible at 200 Kelvin. For single layer graphene we observe that while nanopatterning decreases the electron mobility, the spin lifetime increases from 200 ps to 500 ps. This is consistent with a Dyakonov-Perel-like contribution to spin relaxation. In bilayer graphene, we observe a low electron mobility and high spin lifetimes of about 1 ns in both bulk and nanoribbons, again consistent with Dyakonov-Perel-like spin relaxation. Attempting to see an influence of possible magnetic moments at the sample edges, no clear signature was detected in the Hanle data at 200 Kelvin.

MA 25.4 Wed 10:15 POT 051

THz radiation interacting with epitaxial graphene — •Christian Sorger, Sascha Preu, and Heiko B. Weber — Lehrstuhl für Angewandte Physik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

We investigate the interaction between terahertz (THz) radiation and periodically doped graphene ribbons. We find a remarkable polarization dependence. The Drude response of graphene can be probed with THz electric fields parallel to the ribbons. This results in a high-pass filter-like behavior with a 3dB-frequency in the THz range. The exact value depends on carrier mobility and carrier concentration. For THz electric field perpendicular to the ribbons we detect rather high transmission as the response is dominated by plasmonic effects. Utilizing the material system epitaxial graphene on silicon carbide (SiC) we show that no lithographic patterning is required to couple light into the two-dimensional electron gas (2DEG). As the interaction strength depends on the geometry of the 2DEG and its electronic properties, respectively, this strategy allows for a characterization of the AC conductivity in epitaxial graphene.

MA 25.5 Wed 10:30 POT 051

Numerically exact approach to transport properties of disordered two-dimensional materials — •Stefan Barthel[1,2], Malte Rösner[1,2], Fernando Gargiulo[3], Oleg V. Yazyev[3], and Tim O. Wehling[1,2] — [1]Institut für Theoretische Physik, Universität Bremen, Germany — [2]Bremen Center for Computational Materials Science, Universität Bremen, Germany — [3]Institute of Theoretical Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland

We present a numerical method for modeling electron transport in disordered two-dimensional materials such as graphene with resonant impurities. Covalently bonded adatoms, such as hydrogen, modify the electronic structure and transport properties of graphene in the diffusive as well as localized regime in which quantum corrections become important. The electronic structure is described using a tight-binding model involving pz-orbitals on a honeycomb lattice, whereas the transport properties are evaluated in the linear response approximation (Kubo-Greenwood) using the kernel polynomial method as a solver. By combining these methods we gain access to large systems containing up to 10ˆ6 atoms. These results are compared to the ones obtained using the Landauer-Büttiker approach in the above-mentioned transport regimes.

MA 25.6 Wed 10:45 POT 051

Quantum Hall Effect in Chemically Functionalized Graphene: Defect-Induced Critical States and Breakdown of Electron-Hole Symmetry — •Nicolas Leconte[1,2], Jean-Christophe Charlier[2], and Stephan Roche[1] — [1]ICN2 - Institut Catala de Nanociencia i Nanotecnologia, Campus UAB, 08193 Bellaterra (Barcelona), Spain — [2]Université catholique de Louvain (UCL), Institute of Condensed Matter and Nanoscience (IMCN), Chemin des étoiles 8, 1348 Louvain-la-Neuve, Belgium

Unconventional magneto-transport fingerprints in the quantum Hall regime (with applied magnetic field from one to several tens of Tesla) in chemically functionnalized graphene are reported. Upon chemical adsorption of monoatomic oxygen (from 0.5% to few percents), the electron-hole symmetry of Landau levels is broken, while a double-peaked conductivity develops at low-energy, resulting from the formation of critical states conveyed by the random network of defects-induced impurity states. Scaling analysis suggests an additional zero-energy quantized Hall conductance plateau, which is here not connected to degeneracy lifting of Landau levels by sublattice symmetry breakage. This singularly contrasts with usual interpretation, and unveils a new playground for tailoring the fundamental characteristics of the quantum Hall effect. The study on oxygen is complemented with a study on a simplified divacancy model, confirming the percolation of impurity states leading to delocalized states.

Coffee break (15 min.)

MA 25.7 Wed 11:15 POT 051

Ultra long spin decoherence times in graphene quantum dots with a small number of nuclear spins — •Moritz Fuchs[1], John Schliemann[2], and Björn Trauzettel[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg — [2]Institut für Theoretische Physik, Universität Regensburg, 93053 Regensburg

We study the dynamics of an electron spin in a graphene quantum dot, which is interacting with a bath of less than ten nuclear spins via the anisotropic hyperfine interaction. Due to substantial progress in the fabrication of graphene quantum dots, the consideration of such a small number of nuclear spins is experimentally relevant. This choice allows us to use exact diagonalization to calculate the longtime average of the electron spin as well as its decoherence time. We investigate the dependence of spin observables on the initial states of nuclear spins and on the position of nuclear spins in the quantum dot. Moreover, we analyze the effects of the anisotropy of the hyperfine interaction for different orientations of the spin quantization axis with respect to the graphene plane. Interestingly, we then predict remarkable long decoherence times of more than 10ms in the limit of few nuclear spins.

MA 25.8 Wed 11:30 POT 051

Carrier dynamics in graphene under Landau quantization — •Florian Wendler[1], Martin Mittendorff[2], Stephan Winnerl[2], Manfred Helm[2], Andreas Knorr[1], and Ermin Malic[1] — [1]Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

We investigate the ultrafast dynamics of low-energetic Dirac electrons in graphene under Landau quantization [1]. In a joint experiment-theory study, we provide calculations based on the density matrix formalism [2] as well as measurements of the relaxation dynamics via differential transmission spectroscopy.

As a consequence of the linear dispersion at the Dirac points, graphene exhibits a non-equidistant Landau level spectrum which allows to address specific transitions by optical pumping. Exploiting this to selectively excite the energetically lowest Landau levels, we employ pump-probe spectroscopy to explore the carrier dynamics in this regime. A surprising sign reversal in differential transmission spectra is observed both in experiment and theory and provides evidence for strong Auger scattering on a picosecond timescale. Our calculations even predict the occurrence of a substantial carrier multiplication in Landau quantized graphene [3].

[1] M. Mittendorff et al., (in preparation).
[2] E. Malic, A. Knorr, Graphene and Carbon Nanotubes: Ultrafast Optics and Relaxation Dynamics, (Wiley-VCH, Berlin, 2013).
[3] F. Wendler, A. Knorr, and E. Malic, (submitted).

MA 25.9 Wed 11:45 POT 051

Polarization dependence of optical carrier excitation in graphene — •Martin Mittendorff[1,2], Torben Winzer[3], Ermin Malic[3], Andreas Knorr[3], Harald Schneider[1], Manfred Helm[1,2], and Stephan Winnerl[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany — [3]Technische Universität Berlin, Hardenbergstraße 36 10623 Berlin, Germany

We present near-infrared pump-probe measurements to investigate the polarization dependence of optical carrier excitation in graphene. Excitation with linearly polarized radiation leads to an anisotropic distribution of the nonequilibrium carriers in momentum space. This anisotropy can be revealed by the comparison of pump-probe signals for different polarization configurations. In parallel configuration the probe beam has the same polarization with respect to the pump beam, for the perpendicular configuration the polarization of the probe beam is rotated by 90°. The signal amplitude of the parallel configuration is about twice as large as compared to the perpendicular configuration. The initial relaxation process is faster for the parallel polarized probe beam, which leads to identical signals about 150 fs after excitation. At this time delay an isotropic carrier distribution is reached by electron-phonon scattering. These findings are confirmed by microscopic calculations.

MA 25.10 Wed 12:00 POT 051

Anisotropic photoinduced current injection in graphene — •Julien Rioux[1], John Sipe[2], and Guido Burkard[1] — [1]University of Konstanz — [2]University of Toronto

Quantum-mechanical interference effects are considered in carrier and charge current excitation in gapless semiconductors using coherent optical field components at frequencies ω and 2ω. Due to the absence of a bandgap, excitation scenarios outside of the typical operation regime are considered; we calculate the polarization and spectral dependence of these all-optical effects for single- and bilayer graphene. For linearly-polarized light and with one-photon absorption at ω interfering with 2ω absorption and ω emission, the resulting current injection is five times stronger for perpendicular polarization axes compared to parallel polarization axes. This additional process results in an anisotropic current as a function of the angle between polarization axes, in stark contrast with the isotropic current resulting from the typical interference term in graphene [Rioux et al., PRB 83, 195406 (2011)]. Varying the Fermi level allows to tune the disparity parameter $d = \eta_I^{xyyx}/\eta_I^{xxxx}$ closer to typical values in GaAs [$|d| \approx 0.2$, Rioux and Sipe, Physica E 45, 1 (2012)]: from -1, when the additional process is fully Pauli-blocked, to $-3/7$, when it is fully accessible, thus facilitating polarization sensitive applications.

MA 26: Topological insulators: Theory (with HL/O/TT)

Time: Wednesday 9:30–11:15 Location: POT 151

MA 26.1 Wed 9:30 POT 151

Stabilizing Chern and fractional Chern insulators — •Adolfo G. Grushin, Johannes Motruk, and Frank Pollmann — Max Planck Institute for the Physics of Complex Systems, Dresden

The experimental realization of Chern insulators (CI) and fractional Chern insulators (FCI), zero field lattice analogues of the integer and fractional Hall effects respectively, is still a major open problem in condensed matter. For the former, it was proposed that short range interactions at the mean-field level can drive a trivial insulator into a CI. For the latter, the effect of band dispersion and sizes of the single-particle gaps with respect to the interaction strength have been argued to be important to stabilize an FCI state. In this talk we will examine the robustness and fate of these statements both with exact diagonalization and infinite density matrix renormalization group (iDMRG).

MA 26.2 Wed 9:45 POT 151

Point contacts and localization in generic helical liquids — •Christoph P. Orth, Grégory Strübi, and Thomas L. Schmidt — University of Basel, Switzerland

We consider two helical liquids on opposite edges of a two-dimensional topological insulator, which are connected by one or several local tunnel junctions. In the presence of spatially inhomogeneous Rashba spin-orbit coupling, the spin of the helical edge states is momentum dependent, and this spin texture can be different on opposite edges. We demonstrate that this has a strong impact on the electron transport between the edges. In particular, in the case of many random tunnel contacts, the localization length depends strongly on the spin textures of the edge states.

MA 26.3 Wed 10:00 POT 151

***ab-initio* investigation of topological states and symmetry inversion in HgTe-CdTe Quantum wells** — •Sebastian Kuefner, Juergen Furthmueller, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany

Topological insulators (TIs) recently attracted a high level of attention in solid state physics due to their unique physical properties. Generally, a TI is a material that is insulating in the bulk but exhibits metallic surface or edge states. These states are topologically protected which means that they are independent of surface orientation and passivation. The edge states usually have linear band dispersion forming Dirac cones.

The electromagnetic properties of the edge states might be used for the realisation of topological superconducting phases. In two dimensions the edge states build the quantum spin Hall state (QSH). In 2006, Bernevig et al. predicted the occurence of the QSH in HgTe-CdTe superlattices theoretically by an **kp**-approch which was later verified by König et al. experimentally.

However, these results have not yet been discussed in the framework of a reasonable electronic structure theory based on *ab-initio* methods but account for quasiparticle effects and spin-orbit coupling. Using density-functional theory together with the Tran-Blaha approximation we discuss the occurence of topological quantum-well states and investigate the topological transition in atomic structures.

MA 26.4 Wed 10:15 POT 151

Nontrivial Interface States Confined Between Two Topological Insulators — •Tomáš Rauch[1], Markus Flieger[1], Jürgen Henk[1], 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, D-06120 Halle (Saale), Germany

By *ab initio*-based tight-binding calculations, we show that nontrivial electronic states exist at an interface of a $\mathcal{Z}_2$ topological insulator and a topological crystalline insulator. At the exemplary (111) interface between Bi_2Te_3 and SnTe, the two Dirac surface states at the Brillouin zone center $\overline{\Gamma}$ annihilate upon approaching the semi-infinite subsystems but one topologically protected Dirac surface state remains at each time-reversal invariant momentum $\overline{\mathrm{M}}$. This leads to a highly conducting spin-momentum-locked channel at the interface but insulating bulk regions. For the Sb_2Te_3/Bi_2Te_3 interface we find complete annihilation of Dirac states because both subsystems belong to the same topology class.

MA 26.5 Wed 10:30 POT 151

Natural three-dimensional topological insulators in Tl_4PbTe_3 and Tl_4SnTe_3 — •Chengwang Niu[1,2], Ying Dai[1], Baibiao Huang[1], Gustav Bihlmayer[2], Yuriy Mokrousov[2], Daniel Wortmann[2], and Stefan Blügel[2] — [1]School of Physics, Shandong University, Jinan, China — [2]Peter Grünberg Institut (PGI-1) & Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The recently discovered three-dimensional topological insulators have attracted much interest due to their exceptional properties of possessing insulating bulk but time-reversal symmetry protected metallic surfaces with Dirac-like band structure [1,2]. The search for new topological insulators is critical for both fundamental and practical interests. Based on first-principles calculations, we reveal that both Tl_4PbTe_3 and Tl_4SnTe_3 are strong topological insulators with different band inversion behaviors at Γ point [3]. The mechanisms of band inversion in Tl_4PbTe_3 and Tl_4SnTe_3, as well as in Bi_2Se_3 and Sb_2Se_3, are investigated and classified. The Z_2 topological invariants and topological surface states are investigated to confirm the topologically non-trivial phase. Our calculations further indicate that the electron- or hole-type Dirac fermion can be effectively engineered by hole doping, which is necessary for device applications of topological insulators.

[1] M. Hasan and C. Kane, Rev. Mod. Phys. **82**, 3045 (2010).
[2] X.-L. Qi and S.-C. Zhang, Rev. Mod. Phys. **83**, 1057 (2011).
[3] C. Niu et al., in preparation.

MA 26.6 Wed 10:45 POT 151

Electronic properties of the topological crystalline insulator SnTe and its (001) and (111) surfaces: an ab-initio study — •Matthias Drüppel, Peter Krüger, and Michael Rohlfing — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster

The insulator SnTe belongs to the recently discovered class of materials in which a crystalline symmetry ensures the existence of topologically protected surface states. We report on the properties of these states at the (001) and (111) surfaces. To this end, we have employed density-functional theory.

The bulk band structure of SnTe is characterized by inversion at the four equivalent L points giving rise to a mirror Chern number $n_m = -2$. The (001) surface exhibits two mirror planes and shows four Dirac cones at non-time-reversal-invariant points along the $\pm\bar{\Gamma}\bar{\mathrm{X}}$ and $\pm\bar{\Gamma}\bar{\mathrm{X}}'$ lines, respectively. Here we explore the influence of lattice deformations on the stability of the surface states. Our results reveal that distortions of the topmost layers which break a mirror symmetry locally at the surface do *not* lead to an opening of the surface band gap. We find that only*bulk* lattice deformations, e.g. rhombohedrial distortions, that break one or both mirror symmetries also in the bulk part of the system give rise to a surface band gap. Our calculations show that the Sn terminated (111) surface exhibits Dirac cones centered at $\bar{\Gamma}$ and $\bar{\mathrm{M}}$. In particular at the $\bar{\mathrm{M}}$ point, these topologically protected states are distinctly extended into the bulk. Interestingly, we observe for the Te terminated (111) surface a gap-closing Dirac state only at the $\bar{\Gamma}$ point

MA 26.7 Wed 11:00 POT 151

Adsorbate- and vacancy-induced band bending in Bi_2Se_3: ab-initio calculations — •Tobias Förster, Peter Krüger, and Michael Rohlfing — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität, 48149 Münster, Germany

Bi_2Se_3 is one of the first topological insulators ever discovered. It has been widely studied both experimentally und theoretically, due to its simple electronic structure with only one Dirac point at $\bar{\Gamma}$. In experiments, a downward band bending and an ageing effect are frequently observed. This has been attributed to an intrinsic n-doping and to coverage with adsorbates. Models for the band bending mostly focussed on the intrinsic doping.

Using DFT calculations, we show that a long-ranged potential also occurs for an adsorbate-covered surface, even without intrinsic doping. As a prototype adsorbate, we have investigated potassium at various coverages. The resulting changes in the charge density, the potential, and the band structure can be attributed to two distinct origins: short-ranged adsorbate-specific changes and the formation of a long-ranged potential (which is independent of the specific adatom). We will explain how the band bending is related to the layered structure of Bi_2Se_3. Similar effects result from our calculations for different types of adsorbates as well as for selenium vacancies in the surface layer.

MA 27: Spintronics 1 (with HL/TT)

Time: Wednesday 10:15–12:00 Location: POT 006

MA 27.1 Wed 10:15 POT 006

Spin dynamics on the metallic side of the metal to insulator transition — •Jan G. Lonnemann, Kim Niewerth, Jens Hübner, and Michael Oestreich — Leibniz Universität Hannover - Abteilung Nanostrukturen, Hannover, Germany

Several theoretical works treat the spin dynamics in zinc-blende semiconductors, like GaAs, around the metal-to-insulator transition. Most of them fail to explain the extremely long lifetimes experimentally observed [1]. Recently, it was argued that the Dyakonov-Perel mechanism (DP), usually only applicable in the conduction band, can be extended towards hopping transport (HT) present in the impurity band [2]. The theoretical calculations predict a dependence on the carrier density differing strongly from the DP spin relaxation expected for the conduction band electrons. We present extremely low excitation Hanle depolarization measurements on precisely n-doped MBE grown samples in the range of carrier concentrations from 2 to $10 * 10^{16}$ cm^{-3}. The density dependence of the spin lifetimes extracted from our measurements indicates that the dephasing due to HT is not the dominant mechanism. Remarkably, there is no significant difference in the spin lifetimes obtained from measurements on MBE material, with extremely low compensation ratios, as compared with samples from commercial wafers. This further indicates that dephasing due to HT is not the dominant mechanism, since HT depends strongly on the compensation ratio.

[1] M. Römer et al.; *Phys. Rev. B*, **81**, 075216 (2010).
[2] G.A. Intronati et al.; *Phys. Rev. Lett.*, **108**, 016601 (2012).

MA 27.2 Wed 10:30 POT 006

Nanomechanical read-out and manipulation of a single spin — •Heng Wang and Guido Burkard — University of Konstanz, Department of Physics

The single electron spin in quantum dot is a promising candidate as a qubit for quantum computation and quantum information. We investigate detection as well as manipulation of the single spin in a suspended carbon nanotube quantum dot. The detection and the manipulation are based on the spin-mechanical coupling induced from the intrinsic spin-orbit coupling. We use a Jaynes-Cummings model with a quantized flexural mode of the resonator to describe the system. An external electric field is used to drive the resonator and to induce an the interaction between the single electron in the quantum dot and the external driving field. The spin states can be identified by measuring the mechanical motion of the nanotube, which is detected by observing the current through a nearby charge sensor. Arbitrary-angle rotations about arbitrary axes of the single electron spin can be achieved by varying the frequency and the strength of the external electric driving field.

MA 27.3 Wed 10:45 POT 006

Time-resolved electrical detection of the inverse spin Hall Effect after ps optical excitation — •Manfred Ersfeld[1], Ivan Stepanov[1], Sammy Pissinger[1], Christopher Franzen[1], Sebastian Kuhlen[1], Mihail Lepsa[2], and Bernd Beschoten[1] — [1]2nd Institute of Physics, RWTH Aachen University, Germany — [2]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich GmbH, Germany

Electrical detection of spin currents give an insight into the microscopic mechanisms of spin transport and play an important role in spin electronics. In previous experiments spin currents due to spin Hall effect have been imaged in optical measurements as spin accumulation.[1]

Here we report on the first time-resolved electrical detection of spin precession in n-InGaAs in time-resolved measurements of the inverse spin Hall effect. Net spin currents are achieved by applying electric fields and by polarization of the electrons with circularly polarized picosecond laser pulses. Electron spin precession in an external magnetic field can be monitored using a phase-triggered sampling oscilloscope as an oscillating voltage perpendicular to the applied electric field. Temperature dependent measurements of the spin Hall effect are presented. Time-resolved Faraday rotation measurements on the same sample under identical experimental conditions show good agreement between the measured spin dephasing times and the g-factor in the spin Hall measurements.

This Work has been supported by DFG through FOR 912

[1] Y. K. Kato et al., Science 306, 1910 (2004)

MA 27.4 Wed 11:00 POT 006

Terahertz out-of-plane resonances due to spin-orbit coupling — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP)Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

A microscopic kinetic theory is developed which allows to investigate non-Abelian SU(2) systems interacting with mean fields and spin-orbit coupling under magnetic fields in one, two, and three dimensions. The coupled kinetic equations for the scalar and spin components are presented and linearized with respect to an external electric field. The dynamical classical and quantum Hall effect are described in this way as well as the anomalous Hall effect for which a new symmetric dynamical contribution to the conductivity is presented. The coupled density and spin response functions to an electric field are derived including arbitrary magnetic fields. The magnetic field induces a staircase structure at frequencies of the Landau levels. It is found that for linear Dresselhaus and Rashba spin-orbit coupling a dynamical out-of-plane spin response appears at these Landau level frequencies establishing terahertz resonances. (EPL, 104 (2013) 2700)

MA 27.5 Wed 11:15 POT 006

Resonant spin amplification in intrinsic bulk germanium — •Jan Lohrenz, Timo Paschen, and Markus Betz — Experimentelle Physik 2, TU Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund

Recent experiments have revealed the possibility to optically orient electron spins in bulk germanium via indirect optical transitions. However, the temporal limitations to both the spin lifetime and the coherence of photogenerated electrons have remained unexplored so far. Here we demonstrate resonant spin amplification in intrinsic bulk germanium using a 90 MHz femtosecond pulse train at 0.8 eV central photon energy. Most importantly, we find remarkably long spin lifetimes exceeding 50 ns at temperatures of up to 60 K, limited by Elliott Yafet type processes. Consistent with model simulations we also find pronounced signatures of the g-factor anisotropy in germanium in the resonant spin amplification data.

MA 27.6 Wed 11:30 POT 006

Ultrahigh Bandwidth Spin Noise Spectroscopy — •Fabian Berski, Hendrik Kuhn, Jan G. Lonnemann, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

We advance all optical spin noise spectroscopy (SNS) in semiconductors to detection bandwidths of several hundred gigahertz by employing a sophisticated scheme of pulse trains from ultrafast laser oscillators as an optical probe [1]. The ultrafast SNS technique avoids the need for optical pumping and enables nearly perturbation free measurements of extremely short spin dephasing times. We apply the technique to highly-n-doped bulk GaAs where magnetic field dependent measurements show unexpected large g-factor fluctuations. Calculations suggest that such large g-factor fluctuations do not necessarily result from extrinsic sample variations but are intrinsically present in every doped semiconductor due to the stochastic nature of the dopant distribution.

[1] Berski, F., et al., Phys. Rev. Lett. **111**, 186602 (2013).

MA 27.7 Wed 11:45 POT 006

Effect of Nuclear Quadrupole Moments on Electron Spin Coherence in Semiconductor Quantum Dots — •Erik Welander[1], Evgeny Chekhovich[2], Alexander Tartakovskii[2], and Guido Burkard[1] — [1]Department of Physics, University of Konstanz, Germany — [2]Department of Physics and Astronomy, University of Sheffield, United Kingdom

We theoretically investigate the influence of the fluctuating Overhauser field on the spin of an electron confined to a quantum dot. The fluctuations arise from nuclear spin being exchanged between different nuclei via the nuclear magnetic dipole coupling. We focus on the role of the nuclear interaction from electric quadrupole moments (QPM), which generally cause a reduction in internuclear spin transfer efficiency. By dividing the nuclear problem into subcells we are able to describe $10^4 - 10^5$ nuclei, which are realistic numbers for a quantum dot. The effects on the electron spin coherence time are studied by modeling an electron spin echo experiment. We find that the QPM cause an increase in the electron spin coherence time and that an inhomogeneous distribution, where different nuclei have different QPM, causes an even larger increase than a homogeneous distribution.

MA 28: Magnetic Materials I

Time: Wednesday 15:00–17:45 Location: HSZ 04

MA 28.1 Wed 15:00 HSZ 04

Thickness and strain dependent electric transport in Sr2IrO4 thin films — •chengliang lu[1], dietrich hesse[1], and marin alexe[1,2] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [2]Department of Physics, Warwick University, Coventry CV4 7AL, United Kingdom

Sr2IrO4, which is highly analogous to the p-wave superconductor Sr2RuO4 and Fermi liquid metal Sr2RhO4 in the crystalline structure, is an unexpected weak ferromagnetic insulator. The cooperation of strong spin-orbit coupling (˜0.5 eV) and on-site Coulomb repulsion is responsible for the insulating ground state. Recently, a giant magnetoelectric effect and a lattice-driven magnetoresistance were evidenced in Sr2IrO4 bulk single crystals, and the magnetic field modulated Ir-O-Ir bond angle was proposed to be the origin, which suggests a high sensitivity of the physical properties of Sr2IrO4 to the lattice modulation. Here we investigate the thickness and strain dependent electric transport behavior in Sr2IrO4 thin films grown on various substrates. The electric transport of all samples can be well fitted by the variable-range-hopping model. Interestingly, the magnetoresistance behavior of the films is distinct from the bulk counterpart, which implies the strong coupling of spin, lattice, and orbit in Sr2IrO4.

MA 28.2 Wed 15:15 HSZ 04

Double exchange via t_{2g} orbitals and Jahn-Teller effect in ferromagnetic $La_{0.7}Sr_{0.3}CoO_3$ probed by epitaxial strain — •Dirk Fuchs, Michael Merz, Peter Nagel, Rudolf Schneider, Stefan Schuppler, and Hilbert von Löhneysen — Karlsruhe Institute of Technology, Karlsruhe, Germany

The magnetic exchange in hole-doped ferromagnetic cobaltates is investigated by studying the magnetic and electronic properties of $La_{0.7}Sr_{0.3}CoO_3$ films as a function of epitaxial strain. We found a strong-coupling double exchange mechanism between Co^{3+} and Co^{4+} high-spin states mediated by t_{2g} electrons in contrast to the moderate coupling provided by the e_g-exchange in manganites. The strong sensitivity of the Curie temperature T_C to the bulk compression can be explained by the small bandwidth of the t_{2g}-derived states. A strain-induced Jahn-Teller effect is likewise observed. The experimental results clarify the magnetic exchange mechanism in the cobaltates.

MA 28.3 Wed 15:30 HSZ 04

Fe-Co-X films with spontaneous strain and increased magnetocrystalline anisotropy — •Ludwig Reichel[1,2], George Giannopoulos[3], Martin Hoffmann[1,2], Steffen Oswald[1], Dimitris Niarchos[3], Ludwig Schultz[1,2], and Sebastian Fähler[1,4] — [1]IFW Dresden, PF 270116, 01171 Dresden — [2]TU Dresden, 01069 Dresden — [3]Demokritos NCSR, 15310 Athens, Greece — [4]TU Chemnitz, 09107 Chemnitz

Permanent magnets are ubiquitous. Within the last years, abundance of the rare-earth based alloys has been questioned, but alternatives are still missing. Fe-Co alloy was considered a promising candidate as it provides a very high magnetic moment. A remarkable magnetocrystalline anisotropy (MCA), which is a condition for permanent magnets, is proposed when its cubic unit cell is strained tetragonally [1]. However, in thin films, the strain relaxes within few monolayers. Recently, it was proposed that a low fraction of carbon atoms stabilises the strain and leads to a high MCA [2].

In this study, interstitials as C and B were alloyed to Fe-Co. The films were prepared using PLD. In situ RHEED allowed for an investigation of film relaxation. It was observed, that the relaxation stopped at a c/a ratio of approx. 1.03 i.e. tetragonally distorted. This residual strain is also present in films of thicknesses up to 100 nm and indicates the formation of spontaneously strained Fe-Co-X films. Magnetic measurements demonstrate the influence of strain on magnetic anisotropy.

[1] Burkert et al. Phys. Rev. Let. 93 (2004) 027203
[2] Delczeg-Czirjak et al. submitted (2013)

MA 28.4 Wed 15:45 HSZ 04

Annealing influence on the Gilbert damping parameter and the exchange constant of CoFeB thin films — •Andres Conca, Evangelos Th. Papaioannou, Stefan Klingler, Jochen Greser, Thomas Sebastian, Britta Leven, and Burkard Hillebrands — FB Physik und Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

The search for materials with low-damping properties is very active due to their importance for many fields such as spin-waves experiments, STNOs or for other purposes in magnon spintronics. In this sense, CoFeB is a very promising material with low damping constant values. It is known that an annealing step is required to induce a crystallization of the as-deposited amorphous CoFeB thin films.

A low damping value of $\alpha = 0.0042$ and an exchange constant of $A = 1.5\times10^{-11}$ J/m for as-deposited $Co_{40}Fe_{40}B_{20}$ thin films have been recently reported by us [1]. Now, we report on the influence of the annealing temperature on these and other film properties.

The films were studied by measuring the ferromagnetic resonance using a strip-line vector network analyzer (VNA-FMR). The results are shown for 78 nm thick films annealed at 200-400°C during 30 min. The meaning of the results and the correlation with the crystallization process measured by x-ray diffraction is discussed.

Support by the state of Rhineland-Palatinate (MBWWK and MWKEL) and by the ERDF programm in the frame of the Spintronic Technology Platform (STeP) is gratefully acknowledged.

[1] J. Appl. Phys. **113**, 213909 (2013).

MA 28.5 Wed 16:00 HSZ 04

Buffer-free iron nitride epitaxial thin films — Daniel Bick, Jose Kurian, •Imants Dirba, Oliver Gutfleisch, and Lambert Alff — Institute of Materials Science,Technische Universität Darmstadt, Darmstadt, Deutschland

α''-$Fe_{16}N_2$ is one of the most intensively discussed candidates of rare-earth free permanent magnet materials. We use molecular beam epitaxy for evaluating iron nitride phases in order to understand their magnetic behavior. In current literature, such films are often grown on Fe buffer layers which makes it difficult to exactly determine their magnetization. Here we report on buffer-free or direct growth of Fe nitride phases on oxide substrates. Depending on the nitridation condition using a nitrogen radical source we have successfully grown epitaxial thin films of Fe, FeN, Fe_4N and α'-Fe_8N. Due to the tiny thermodynamic phase space where α''-$Fe_{16}N_2$ forms, it is difficult to obtain this phase without post-deposition annealing. Our preliminary magnetization measurements indicate a reduced magnetic saturation of α'-Fe_8N as compared to literature values.

15 min. break

MA 28.6 Wed 16:30 HSZ 04

Tunnel magnetoresistance in double barrier magnetic tunnel junctions with different free layer deposition conditions — •Ciarán Fowley[1], Wen Feng[1], Huadong Gan[1], René Hübner[1], Annette Kunz[1], Jürgen Lindner[1], Jürgen Fassbender[1,2], JMD Coey[3], and Alina Deac[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, POB 51 01 19, 01314 Dresden, Germany — [2]Institute for Physics of Solids, TU Dresden, Zellescher Weg 16, 01069 Dresden, Germany — [3]School of Physics, Trinity College Dublin, Ireland

Double barrier magnetic tunnel junctions (DB-MTJs) allow for operation at higher bias voltages than their single barrier counterparts, but their total tunnelling magnetoresistance (TMR) ratio is still less than in the single barrier case.[1] Here, we prepare CoFeB/MgO-based DB-MTJs with differing free layer deposition conditions. The deposition conditions for the outer CoFeB electrodes and the MgO barriers were kept the same. The middle CoFeB layer was deposited at differing sputtering power densities (from 1.3 to 4.4 W/cm^2) to vary the B concentration.[2] Contributions of the upper and lower junction to the total TMR were compared as a function of sputtering power density and annealing temperature. As the sputtering power density of the free layer is increased the TMR response of the upper and lower junctions is opposite, indicating that the growth of both MgO on CoFeB as well as CoFeB on MgO is sensitive to B content. This is attributed to the suppression of B diffusion which is confirmed by transmission electron microscopy analysis. [1] T. Nozaki et al., Appl. Phys. Lett., 86, 082501 (2005). [2] H.D. Gan et al., IEEE Trans. Magn. 47, 1567 (2011).

MA 28.7 Wed 16:45 HSZ 04

Substrate polarization dependent magnetic and microstructural properties of high-quality Fe_3O_4/ZnO interfaces — •Michael Zapf[1], Ozan Kirilmaz[1], Sebastian Brück[1], Nadezda Tarakina[1], Nina-Juliane Steinke[2], Eberhard Goering[3], He Tian[4], Jo Verbeeck[4], Michael Sing[1], and Ralph Claessen[1] — [1]Physikalisches Institut and Röntgen Research Center for Complex Materials Systems, Universität Würzburg, Germany — [2]Rutherford Appleton Laboratory, Chilton, UK — [3]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [4]Electron Microscopy for Materials Science, University of Antwerp, Belgium

Magnetite (Fe_3O_4) is among the most promising materials for use as a spin injector into a semiconducting host such as, e.g. ZnO. We present a detailed study of the interface characteristics of epitaxial MBE-grown Fe_3O_4 films in dependence of the ZnO substrate polarization. We were able to prepare flat terraced surfaces for both Zn- and O-polar (0001) oriented substrates by *ex situ* annealing procedures. X-ray photoemission evidences that the films are phase-pure and stoichiometric. The growth mechanism and bulk film properties have already been investigated in previous publications. We discuss our recent data from polarized neutron and X-ray reflectometry, transmission electron microscopy TEM) and magnetometry on the influence of the chosen substrate termination on magnetism and atomic ordering at the interface of our samples. Furthermore a comprehensive TEM study shows local strain fields arising from the lattice mismatch of Fe_3O_4 and ZnO that lead to a modulated Fe valency at the interface.

MA 28.8 Wed 17:00 HSZ 04

The effect of strain on the orbital occupation of Mn atoms in thin films of $La_{1-x}Sr_{1+x}MnO_4$ — Mehran Vafaee[1], •Philipp Komissinskiy[1], Roberto Kraus[2], Valentina Bisogni[2], Mehrdad Baghaie Yazdi[1], Jochen Geck[2], and Lambert Alff[1] — [1]Institute for Materials Science, Technische Universität Darmstadt, Alarich-Weiss-Straße 2, 64287 Darmstadt, Germany — [2]Leibniz Institute for Solid State and Materials Research, Helmholtzstrasse 20, D-01171 Dresden, Germany

We have investigated the correlation between orbital and lattice degrees of freedom in thin films of single-layered insulating antiferromagnet $La_{1-x}Sr_{1+x}MnO_4$ ($x = 0.0$, 0.5) using linear polarized X-ray absorption spectroscopy at Mn $L_{2,3}$-edges. Lattice parameters of the $La_{1-x}Sr_{1+x}MnO_4$ films are controlled by in-plane compressive and tensile strain induced via their epitaxial growth on $LaSrAlO_4$ and $NdGaO_3$ substrates, respectively [1]. Positive sign of the linear dichroism measured for the films with $x = 0.0$ indicates the preferential out-of-plane $d_{3z^2-r^2}$ orbital occupation for Mn^{3+} cations. Occupation of the in-plane-oriented orbitals in the films with $x = 0.0$ may be possible at the tensile strain larger than 1.9 % used in our experiments. Tetragonal lattice distortions in the strained LSMO films with $x = 0.5$ promote preferential occupation of the out-of-plane-oriented Mn orbitals instead of the $d_{3x^2-r^2}$ and $d_{3y^2-r^2}$ in-plane-oriented ones previously reported for $La_{1-x}Sr_{1+x}MnO_4$ single crystals with similar doping level.

[1] M. Vafaee, M. Baghaie Yazdi, A. Radetinac, G. Cherkashinin, P. Komissinskiy, and L. Alff, J. Appl. Phys. **113**, 053906 (2013).

MA 28.9 Wed 17:15 HSZ 04

X-ray absorption magnetic circular dichroism study on ferromagnetic $SrRuO_3$ — •Stefano Agrestini[1], Zhiwei Hu[1], Nils Hollmann[1], Chang-Yang Kuo[1], Qiang Liu[1], Eric Pellegrin[2], Pierluigi Gargiani[2], Philipp Gegenwart[3], Melanie Schneider[3], Sebastian Esser[3], Alexander Komarek[1], and Liu Hao Tjeng[1] — [1]Max Planck Institut CPfS, Dresden, Germany — [2]CELLS-ALBA, Barcelona, Spain — [3]I. Physikalisches Institut, Georg-August-Universität, Göttingen, Germany

$SrRuO_3$ have received intensive research interest because it is one of the very few ferromagnetic metallic 4d transition metal oxides, with a high Curie temperature of T_c=160 K, as well as unusual negative spin polarization and magnetoresistive properties. Ru^{4+} has S=1 spin state, however, very recently it has been suggested that a high spin state (S=2) of Ru^{4+} could be stabilized on compressively in-plane strained $SrRuO_3$ films.

Here we report a study of x-ray magnetic circular dichroism (XMCD) in x-ray absorption (XAS) on the Ru-L2,3 edge on $SrRuO_3$ thin films with different substrate orientations, the (111) and (001) surfaces of $SrTiO_3$. Only a very small directional dependence was found. The XMCD spectra of a $SrRuO_3$ single crystal has been recorded and shows good agreement with the spectral line shape of the thin films. We could not find evidence of the stabilization of a high spin S=2 state. Applying the XMCD sum rules, it can be seen that the orbital momentum of the Ru ions is almost quenched. This surprising finding could be explained by an itinerant character of the Ru electrons.

MA 28.10 Wed 17:30 HSZ 04

Formation of nanostructured NiFe alloy thin films by glancing incidence sputter deposition on nano-rippled Si substrates: an in-situ uGISAXS study — •Sarathlal Koyiloth Vayalil[1], Ajay Gupta[2], Gonzalo Santoro[1], Peng Zhang[1], Shun Yu[1], and Stephan V Roth[1] — [1]Photon Science, Deutsches Elektronen-Synchrotron, Notkestrasse-85, Hamburg, Germany, 22607 — [2]UGC-DAE Consortium for Scientific Research, University Campus, Khandwa Road, Indore, India, 452001.

In this work, growth of potentially important soft magnetic thin films of NiFe alloy on nano-rippled Si substrates at two different deposition geometries (i) normal incidence (ii) glancing angle deposition have been described. The results have been compared with the deposition on pristine Si substrates. Grazing incidence small angle measurements coupled with highly sophisticated sputtering chamber enabled a detailed growth study at nanoscale with time resolution in the order of milliseconds[1]. It has been found that, growth is highly anisotropic along and normal to the ripple wave vectors in both the cases. The annealing followed by the deposition generates large range ordered nanowires of NiFe. Further, ex-situ magnetic measurements have been done using magneto-optical Kerr effect by rotating the sample in azimuthal direction. The mechanism of the observed magnetic anisotropy has been explained by correlating with the GISAXS results.

[1]Dörhmann et al. Rev. Sci. Instrum. 84, 043901 (2013)

MA 29: Magnetization Dynamics II

Time: Wednesday 15:00–18:15 Location: HSZ 401

MA 29.1 Wed 15:00 HSZ 401

Damping due to spin-lattice coupling — •Matthias Assmann and Ulrich Nowak — University Konstanz, 78457 Konstanz, Germany

The Landau-Lifshitz-Gilbert equation is often used for modeling spin dynamics on atomistic length scales. This phenomenological approach to relaxation accumulates all dissipative effects in the damping constant α, no matter whether they are due to interactions with the electronic system or the lattice.
In this talk we present an investigation of the influence of direct spin-lattice coupling on magnetic relaxation processes. We perform spin-molecular dynamics simulations, which take into account the spatial as well as the spin degrees of freedom, both of which are coupled appropriately.
Especially we are interested in the temperature dependence of the relaxation processes. As an example the behavior of small nickel clusters in an external magnetic field will be presented, the resulting damping mechanism as well as the Einstein-de Haas effect.

MA 29.2 Wed 15:15 HSZ 401

Comparison of different theories for femtosecond demagnetization — •Karel Carva[1,2], Dominik Legut[3], Marco Battiato[2], and Peter M. Oppeneer[2] — [1]Charles University in Prague, Czech Republic — [2]Uppsala University, Sweden — [3]VSB-Technical University of Ostrava, Czech Republic

Magnetization can be changed by means of very strong laser light on the femtosecond timescale. The Elliott-Yafet electron-phonon spin-flip (EY-SF) scattering has been suggested to be the dominant responsible microscopic mechanism [1]. However, ab initio calculations of EY-SF scattering have found the demagnetization rate to be too low to explain the observed demagnetization, especially for electrons in the thermalized state [2]. A recent publication [3] suggests that a different computational approach must be adopted for EY-SF calculation, which leads to a higher calculated demagnetization rate.

We have calculated the spin-flip Eliashberg function for three ferromagnetic metals Fe, Co and Ni [4]. We consider both thermalized very hot electron distributions, as well as highly non-equilibrium electron distributions that are expected to be present immediately after the fs laser excitation. Based on this we study the difference between the proposed models and the physical relevance of the employed approximations.

[1] B. Koopmans et al., Nature Mater. 9, 259 (2010). [2] K. Carva, M. Battiato, P. M. Oppeneer, Phys. Rev. Lett., 107, 207201 (2011) [3] A.J. Schellekens, B. Koopmans, Phys. Rev. Lett. 110, 217204 (2013) [4] K. Carva et al., Phys. Rev. B 87, 184425 (2013)

MA 29.3 Wed 15:30 HSZ 401

Ultrafast demagnetization after laser irradiation: The influence of reduced exchange splitting — •Christian Illg, Michael Haag, and Manfred Fähnle — Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany

Electron-phonon scattering is one possible candidate to explain ultrafast demagnetization after laser irradiation in Ni, Fe or Co [1]. We calculate the demagnetization time and the demagnetization rate with ab-initio density-functional theory and estimate the phase space for scattering which is related to the maximum possible demagnetization. We do this for the ground-state band structure and for band structures with reduced exchange splitting (according to reduced magnetic moments). We find that both demagnetization rate and phase space are too small for reasonable excitations to explain the experimental demagnetization [2].

[1] M. Fähnle, C. Illg, J. Phys.: Condens. Matter **23**, 493201 (2011)
[2] C. Illg, M. Haag, M. Fähnle, Phys. Rev. B, in press (2013)

MA 29.4 Wed 15:45 HSZ 401

Ultrafast demagnetization in transition metals - comparing ab-initio electron-phonon and electron-magnon rates — •Michael Haag, Christian Illg, and Manfred Fähnle — Max Planck Institute for Intelligent Systems, D-70569 Stuttgart, Heisenbergstr. 3, Germany

In 1996 Beaurepaire [1] found that a thin ferromagnetic Ni film, which is excited by a fs laser pulse, exhibits an ultrafast demagnetization on 100fs timescale. Despite years of fruitful research the underlying mechanisms remain unclear. Many mechanisms have been suggested including electron-phonon, and electron-magnon spin flips. Carpene [2] suggested that electron-magnon scattering can describe the demagnetization, because in presence of spin-orbit coupling, where spin- is transferred to orbital-angular momentum, which is rapidly quenched by the crystal field. Since the angular momentum is conserved [3] it has to be transferred to the lattice to allow the demagnetization. However Illg [4] could prove that rates and available phase space of electron-phonon coupling alone are too small to explain the demagnetization. We calculate the electron-magnon rates to check whether a combined process of electron-magnon and electron-phonon scatterings explains ultrafast demagnetization. In addition Carpene's assumption is checked by calculating the transferred orbital angular momentum rate.

[1] E. Beaurepaire, et al., Phys. Rev. Lett. 76, 4250 (1996)
[2] E. Carpene, et al., Phys. Rev. B 78, 174422 (2008)
[3] M. Fähnle, et al., J. Magn. Magn. Mater. 347, 45 (2013)
[4] C. Illg, M. Haag, M. Fähnle, Phys. Rev. B. accepted

MA 29.5 Wed 16:00 HSZ 401

Ultrafast relaxation dynamics of majority and minority electrons in ferromagnetic metals — Benedikt Y. Mueller, Mirko Cinchetti, Martin Aeschlimann, Hans Christian Schneider, and •Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

It is experimentally well established that irradiating ferromagnetic films with an ultrashort laser pulse leads to a quenching of the magnetization on a subpicosecond timescale [1]. Currently, Elliott-Yafet like spin-flip processes [2,3,4] as well as superdiffusive transport [5] are discussed to cause this effect. Recently, we have shown that the Elliott-Yafet process, including its possibility during electron–electron collisions [3], can quantitatively reproduce ultrafast magnetization dynamics [4]. This is due to a feedback effect: The interplay of the equilibration of chemical potentials and temperatures and a dynamical exchange splitting increases the demagnetization considerably. In this talk we show additional insights how distinct collision processes influence magnetization dynamics. The Boltzmann description allows to switch separate collisions on and off, identifying their microscopic role on the dynamics. We further present the development of transient spin-resolved temperatures, chemical potentials and electronic energies.

[1] Beaurepaire et al., PRL 76, 4250 (1996)
[2] Koopmans et al., NMAT 9, 259 (2010)
[3] Krauss et al., PRB 80, 180407(R) (2009)
[4] Mueller et al., PRL 111, 167204 (2013)
[5] Battiato et al., PRL 105, 027203 (2010)

15 min. break

MA 29.6 Wed 16:30 HSZ 401

***Ab initio* study of relativistic effects in femtosecond magneto-optics** — Ritwik Mondal[1], Karel Carva[1,2], and •Peter M. Oppeneer[1] — [1]Uppsala University, Uppsala, Sweden — [2]Charles University, Prague, Czech Republic

Excitation of a metallic ferromagnet such as Ni with an intensive femtosecond laser-pulse causes an ultrafast demagnetization within approximately 300 fs. It has been proposed that the ultrafast demagnetization, which is measured in femtosecond magneto-optical experiments, could be due to relativistic light-induced processes: either direct light-induced spin-flip processes or coherent relativistic quantum electrodynamics [1,2] (see also [3]). We perform an *ab initio* investigation of the influence of these relativistic effects on the magneto-optical response of Ni. To this end, we compute, first, the influence of relativistic spin-flip transitions, and second, develop a response theory formulation of the additional appearing ultra-relativistic terms in the Foldy-Wouthuysen transformed Dirac Hamiltonian due to the electromagnetic field. This allows us to draw conclusions on the amount of demagnetization that could be achieved by these mechanisms. Financial support from the EU (under grant No. 281043, FemtoSpin) is acknowledged. [1] J.-Y. Bigot, M. Vomir, E. Beaurepaire, Nature

Phys. **5**, 515 (2009). [2] G.P. Zhang, W. Hübner, G. Lefkidis, Y. Bai, T.F. George, Nature Phys. **5**, 499 (2009). [3] K. Carva, M. Battiatio, P.M. Oppeneer, Nature Phys. **7**, 665 (2011).

MA 29.7 Wed 16:45 HSZ 401

Ultrafast electrical control of the exchange interaction — •Johan H. Mentink and Martin Eckstein — Max Planck Research Department for Structural Dynamics, University of Hamburg-CFEL, 22607 Hamburg, Germany

Ultrafast magnetism is concerned with the dynamics of magnetic materials on a timescale of their intrinsic magnetic interactions [1]. The strongest of them is the exchange interaction, which determines the ordering of microscopic spins. In many situations the ultrafast dynamics of magnetization can conveniently be described using (quasi) equilibrium models in which only the (effective) temperature and the magnetization depend on time, leaving the exchange interaction essentially unchanged. Nevertheless, since the exchange interaction is determined by the interactions between the electrons, it can potentially be controlled with electric fields. In this contribution we demonstrate theoretically that ultrafast electrical control of the exchange interactions is indeed possible by studying the Hubbard model out of equilibrium in the regime relevant to Mott insulators and charge-transfer insulators. Furthermore, we show that such ultrafast modification of the exchange interaction can experimentally be detected by measuring the spin resonances that are excited by it.

[1] J. Stöhr and H.C. Siegmann, Magnetism: from fundamentals to nanoscale dynamics, (Springer-Verlag, Berlin Heidelberg 2006).

MA 29.8 Wed 17:00 HSZ 401

Microscopic electronic configurations during ultrafast magnetisation dynamics — Inka Locht[1], Igor Di Marco[1], Silvano Garnerone[2], Raghuveer Chimata[1], Anna Delin[1], Olle Eriksson[1], and •Marco Battiato[1,3] — [1]Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden — [2]Institute for Quantum Computing, University of Waterloo, Waterloo, Canada — [3]Institute of Solid State Physics, Vienna University of Technology, Vienna, Austria

Recent experiments [1,2] have shown the new possibility of generating an increase of magnetisation in Fe upon direct injection of spin from a neighbouring layer. This reopens the unsolved question about the microscopical configuration after ultrafast magnetisation dynamics, requiring an answer that addresses both dynamics on equal footing.

We provide a model for the description of the electronic and magnetic configurations of ferromagnetic Fe undergoing both ultrafast decrease and increase of magnetization. The model is based on the assumption that after the the ultrafast magnetization change is complete the system has achieved a local thermodynamic equilibrium. With statistical arguments it is possible to show that the magnetic configurations in the case of reduced or increased magnetic moment are qualitatively different. The predicted magnetic configurations are then used to compute T-MOKE spectra at the 3p (M) absorption edges which are in excellent agreement with the existing experiments.

[1] Rudolf et al., Nat. Commun. 3, 1037 (2012) [2] Turgut et al., Phys. Rev. Lett. 110, 197201 (2013)

MA 29.9 Wed 17:15 HSZ 401

Gilbert damping tensor within the breathing Fermi surface model: anisotropy and non-locality — •Danny Thonig[1,2] and Jürgen Henk[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

An essential property of magnetic devices is the relaxation rate in magnetic switching which depends strongly on the damping in the magnetization dynamics. The latter enters the Landau-Lifshitz-Gilbert equation as Gilbert damping α and is commonly taken as a phenomenological parameter. Recent experiments predict, however, a complicated behavior of dissipation in low-dimensional systems, which is hardly to explain by a local scalar α. This mismatch calls for a theoretical understanding based on *ab initio* results.

We apply the breathing Fermi surface model [1] in the framework of a renormalized Green function tight-binding approach. Slater-Koster parameters were obtained by genetic-algorithm optimization with respect to first-principles results. Magnetic as well as structural disorder are treated by the coherent potential approximation. The results are non-local Gilbert tensors $\boldsymbol{\alpha}_{ij}$ which depend on the electron, spin and phonon temperatures as well as on the directions of the local magnetic moments.

Our approach is applied to the bulk and to surfaces of Stoner magnets. The non-local tensorial behavior of the damping leads to significant differences with respect to the conventional local scalar treatment.

[1] V. Kamberský. Cz. Journal of Physics B, **34** (1984) 1111

MA 29.10 Wed 17:30 HSZ 401

Supermagnonic Bloch point propagation in cylindrical nanowires — •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

Bloch points (BPs) [1,2] are micromagnetic singularities that can play a decisive role in magnetic switching processes. The archetypal example is a soft-magnetic cylinder [3], where a BP resides in the center of a vortex domain wall (VDW). Micromagnetic theory is not capable to treat BPs and their dynamics correctly, as they represent topological defects and singularities. We used our multiscale-multimodel code [4] that combines an atomistic Heisenberg model with a finite element micromagnetic algorithm to trace Bloch points and to study the dynamics of VDWs driven by an external magnetic field. The results show that, owing to the high stability of VDWs, the combination of BP and VDW can smoothly propagate at supermagnonic velocities above 1000 m/s when it is driven by fields of only a few mT. We further find a limiting BP/VDW propagation velocity that remains unchanged for a broad range of magnetic field values; a feature that could be advantageous for domain-wall based magnetic storage or logic devices.

[1] E. Feldtkeller, Z. Angew. Phys. 19, 530 (1965)
[2] W. Döring, J. Appl. Phys. 39, 1006 (1968)
[3] A. Arrott *et al.*, IEEE Trans. Mag. 15, 1228 (1979)
[4] C. Andreas, A. Kákay, R. Hertel, arXiv:1311.1617 [cond-mat] (2013)

MA 29.11 Wed 17:45 HSZ 401

Energy dissipation of moved magnetic vortices — •Martin Magiera — Fakultät für Physik, Universität Duisburg-Essen

A two-dimensional easy-plane ferromagnetic substrate, interacting with a dipolar tip which is magnetized perpendicularly with respect to the easy plane is studied numerically by solving the Landau-Lifshitz Gilbert equation. The dipolar tip stabilizes a vortex structure which is dragged through the system and dissipates energy [EPL **100**, 27004 (2012)]. Based on Thiele's equation, an analytical expression for the energy dissipation for the limiting case of a vanishing scanning velocity as well as its validity are discussed [EPL **103**, 57004 (2013)]. A magnetic friction number is defined which represents a general criterion for the validity of Thiele's equation and quantifies the degree of nonlinearity in the response of a driven spin configuration.

MA 29.12 Wed 18:00 HSZ 401

ON THE KRAMERS VERY LOW DAMPING ESCAPE RATE FOR POINT PARTICLES AND CLASSICAL SPINS — •William T. Coffey[1], William J. Dowling[2], Yuri P. Kalmykov[3], and Serguey V. Titov[4] — [1]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [2]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [3]University of Perpignan, Perpignan, France — [4]Kotelnikov Institute of Radio Engineering and Electronics, RAS, Russia

The seminal Kramers result for the very low dissipation (VLD) escape rate of point particles from a potential well is rigorously derived by writing following Stratonovich, the Langevin equation (LE) in energy (slow) and configuration (fast) variables which now contain a multiplicative noise term. The corresponding Fokker-Planck equation (FPE) in configuration-energy space may then be written via the Kramers-Moyal expansion merely by calculating the drift and diffusion coefficients from the LE given the Stratonovich interpretation. The configuration-energy LE method may be transparently generalized following transformations given very recently by Dunn et al. [T. Dunn et al., in Fluctuating Nonlinear Oscillators, Ed. by M.I. Dykman, Oxford University Press, Oxford, 2012], to the stochastic motion of classical spins executing Stoner-Wohlfarth orbits in nonaxially symmetric anisotropy-Zeeman potentials which is governed by the Landau-Lifshitz-Gilbert equation yielding an exact expression for the VLD mean first passage time whence the Kramers VLD rate for spins.

MA 30: Experimental methods and magnetic imaging

Time: Wednesday 15:00–18:00 Location: HSZ 403

MA 30.1 Wed 15:00 HSZ 403

Double-ICEBERG pulses: A next step towards global pulse sequence optimization in NMR — •Simone Köcher and Steffen Glaser — Department of Chemistry, TU München, Garching, Germany

ICEBERG-pulses (Inherent Coherence Evolution optimized Broadband Excitation Resulting in constant phase Gradients) include phase evolution during the radio frequency pulse and create a linear phase dispersion [1]. The ICEBERG concept is extended to consider not only a final phase dispersion but also an initial one, hence called double-ICEBERG-pulses. An optimal control optimization routine for double-ICEBERG-pulses with linear phase slopes is developed which is based on the description by unitary rotations [2]. The effects of phase dispersion, flip angle, and pulse duration on the achievable pulse performance are explored and interpreted by an Euler decomposition scheme. This scheme provides a concept for the design and approximation of ideal pulses. The increased flexibility of double-ICEBERG-pulses offers an additional gain in pulse performance and more adaptability in pulse design.

[1] N. I. Gershenzon, T. E. Skinner, B. Brutscher, N. Khaneja, M. Nimbalkar, B. Luy, S. J. Glaser, *J. Magn. Reson.* **192** (2008), 235-243
[2] N. Khaneja, T. Reiss, C. Kehlet, T. Schulte-Herbrüggen, S. J. Glaser, *J. Magn. Reson.* **172** (2005), 296-305

MA 30.2 Wed 15:15 HSZ 403

Grazing Incidence Nuclear Small-Angle X-ray Scattering: an Advanced Scattering Technique for the Investigation of Ordered Magnetic Nanostructures — •Liudmila Dzemiantsova[1,2,3], Kai Schlage[2], Lars Bocklage[1,2,3], Denise Erb[2], Guido Meier[1,3], and Ralf Röhlsberger[1,2] — [1]The Hamburg Centre of Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Deutsches Elektronen Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — [3]University of Hamburg, Institute of Applied Physics, Jungiustr. 11, D-20355 Hamburg, Germany

Grazing incidence nuclear small-angle X-ray scattering (GINSAXS) is a new advanced scattering technique for the magnetic characterization of ordered magnetic nanostructures with sub-nm spatial resolution. While conventional GISAXS is usually employed to investigate lateral structural correlations of the surface morphology, nuclear GISAXS is in addition sensitive to its magnetic state. Here we use GINSAXS to characterize the lateral magnetic configuration in a nanostripe pattern during magnetic reversal and detect a ferro- and an antiferromagnetic state. The origin of this state is a system consisting of different types of nanowires: with and without pads for a domain wall nucleation. Samples were fabricated from 30 nm isotopically enriched permalloy using several steps of electron-beam lithography on silicon substrates. Based on the synchrotron nature of GINSAXS, it will be possible to magnetically characterize complex ordered structures such as spin ice, even under different conditions of pressure and temperature which is hardly accessible for most surface-sensitive magnetic methods.

MA 30.3 Wed 15:30 HSZ 403

Sherman Mapping of Fe(001)-p(1x1)O — •Christian Thiede[1], Christian Langenkämper[1], Kaito Shirai[2], Anke B. Schmidt[1], Taichi Okuda[3], and Markus Donath[1] — [1]Physikalisches Institut, Universität Münster,Germany — [2]Graduate school of Science, Hiroshima University, Japan — [3]Hiroshima Synchrotron Radiation Center, Hiroshima University, Japan

Two major improvements in spin-polarimeter design have been reported recently: (i) Low-energy-electron scattering from oxygen-passivated Fe(001) surfaces, based on exchange interaction, offers long-term stability and a high figure of merit [1,2]. (ii) Specular reflection at high-Z targets, such as W(001), based on spin-orbit interaction, opens the way to multi-channel detection [3,4]. The use of nonmagnetic targets in the latter case complicates the investigation of spin effects in nonmagnetic samples, such as topological insulators.

In our work, we discuss the possibility of using a magnetic target in a display-type spin-polarization detector. We present reflectivity measurements and Sherman maps of a Fe(001)-p(1x1)O target over a wide range of scattering energies and angles. Both quantities contribute to the figure of merit which determines detector performance. Our findings show suitable working points for a new type of exchange-based multi-channel spin-detector with a figure of merit of up to 1.0 x 10^{-2}.

[1] Winkelmann *et al.*, Rev. Sci. Instrum. **79**, 083303 (2008)
[2] Okuda *et al.*, Rev. Sci. Instrum. **79**, 123117 (2008)
[3] Kolbe *et al.*, Phys.Rev. Lett. **107**, 207601 (2011)
[4] Tusche *et al.*, Appl. Phys. Lett. **99**, 032505 (2011)

MA 30.4 Wed 15:45 HSZ 403

Momentum space anisotropy of electronic correlations in Fe and Ni, an analysis of magnetic Compton profiles — •Liviu Chioncel[1,2], Diana Benea[3], Hubert Ebert[4], Igor Di Marco[5], and Jan Minar[4] — [1]Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany — [2]Augsburg Center for Innovative Technologies, University of Augsburg, D-86135 Augsburg, Germany — [3]Faculty of Physics, Babes-Bolyai University, Kogalniceanustr 1, Ro-400084 Cluj-Napoca, Romania — [4]Chemistry Department, University Munich, Butenandstr. 5-13, D-81377 Munchen, Germany — [5]Department of Physics and Astronomy, Division of Materials Theory, Uppsala University, Box 516, SE-75120 Uppsala, Sweden

The total and magnetic resolved Compton profiles are analyzed within the combined density functional and dynamical mean field theory for the transition metal elements Fe and Ni. A rather good agreement between the measured and computed Magnetic Compton profiles (MCPs) of Fe and Ni is obtained with the standard Local Spin Density Approximation (LSDA). By including local but dynamic many-body correlations captured by Dynamical Mean Field Theory, the Magnetic Compton profile is further improved. The second moment of the difference of the total Compton profile taken along the same momentum direction has been used to discuss the strength of electronic correlations in Fe and Ni.

MA 30.5 Wed 16:00 HSZ 403

Imaging of magnetic domains in TbCo alloys through different capping layers using valence band photoemission magnetic circular dichroism — •Philip Thielen[1,2], Markus Rollinger[1], Pascal Melchior[1], Ute Bierbrauer[1], Sabine Alebrand[1], Christian Schneider[1], Michel Hehn[3], Stéphane Mangin[3], Mirko Cinchetti[1], and Martin Aeschlimann[1] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School of Excellence Materials Science in Mainz, Kaiserslautern, Germany — [3]Institut Jean Lamour, Université de Lorraine, France

Imaging of magnetic domains of uncapped terbium cobalt (TbCo) alloy thin films is achievable using magnetic circular dichroism in two-photon photoemission electron microscopy (PEEM)[1]. Here we show imaging of magnetic domains of TbCo alloy thin films through a variety of capping layers. The domain patterns appear identical for samples without and with capping layer but have opposite contrast. Using a time-of-flight detector, we record energy distribution spectra of the photoelectrons. While the MCD signal of uncapped samples depends strongly on the photoelectron spectrum and even shows a sign change in a narrow energy range, we find neither a kinetic energy dependence nor a sign change of the MCD signal for capped samples. We discuss the origin of the magnetic asymmetry in case of the capped samples, distinguishing whether the electrons originate from the capping layer or the underlying TbCo layer itself.

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

15 min. break

MA 30.6 Wed 16:30 HSZ 403

Ultra sensitive magnetic field sensing with single electron spin — •Andrii Lazariev[1], Ganesh Rahane[1], Perunthiruthy Madhu[2], and Gopalakrishnan Balasubramanian[1] — [1]Max Planck Research Group "Nanoscale Spin Imaging", Max Planck Institute for Biophysical Chemistry, Göttingen, Germany — [2]Dept. of Chemical Sciences, TIFR, Mumbai, India

We present an experimental method for the micro- and nanotesla magnetic field measurements using a Nitrogen-Vacancy defect in diamond lattice. The Nitrogen-Vacancy (NV) center in diamond is a lattice defect which appears when a carbon atom is replaced with a nitrogen atom and has a missing lattice node nearby. It can be represented as a pseudo 1/2-spin and sustain its state manipulations under optical or microwave exposure. The NV-center has been proved as a stable nanoscale probe for weak magnetic field. Present work studies a method of Fourier spectroscopy based on modified Phase-Modulated Lee-Goldburg sequence. The study demonstrate the variation of the probe sensitivity to the external magnetic fields and introduces an algorithm based on PMLG sequence allowing to provide the spectra measurements of a multi-frequency (kHz-scale) ultra-weak (uT) magnetic fields.

MA 30.7 Wed 16:45 HSZ 403

A magnetic resonance microscope based on nitrogen-vacancy center in diamond for nanoscale imaging of nuclear spins — Phani Peddibhotla[1], Alexander Gerstmayr[1], Dominik Reitzle[2], Boris Naydenov[1], Berndt Koslowski[2], and •Fedor Jelezko[1] — [1]Institut für Quantenoptik, Universität Ulm, Albert-Einstein-Allee 11, D-89081 Ulm, Germany — [2]Institut für Festkörperphysik, Universität Ulm, Albert-Einstein-Allee 11, D-89069 Ulm, Germany

We report on the development of a scanning probe microscope using nitrogen-vacancy (NV) center in diamond that operates under ambient conditions. Our nuclear magnetic resonance imaging setup comprises of an atomic force microscope (AFM) integrated into an optical confocal microscope . The nanoscale sample under study, containing nuclear spins, is attached onto the tip of an AFM cantilever. The tip is positioned close to a shallow implanted NV center in isotopically purified carbon-12 diamond. Optical readout of the spin quantum state of the NV center encodes information about the magnetic dipolar interaction of sample nuclear spins with the NV electronic spin. Monitoring the fluorescence of the NV center while mechanically scanning the diamond sample with respect to the cantilever tip in three dimensions provides data that could allow the reconstruction of nuclear spin density.

MA 30.8 Wed 17:00 HSZ 403

Imaging of magnetic protein by NV centre in diamond. — •Anna Ermakova[1], Andrea Kurz[1], Goutam Pramanik[2], Jianming Cai[3], Boris Naydenov[1], Tanja Weil[2], Martin Plenio[3], and Fedor Jelezko[1] — [1]Institute of Quantum Optics, University Ulm, Germany — [2]Institute of Organic Chemistry III, University Ulm, Germany — [3]Institute of Theoretical Physics, University Ulm, Germany

To determinate the magnetic structure of a protein it is necessary to use an atomic sited and ultrasensitive magnetic field detector, like the nitrogen-vacancy (NV) centre in diamond. NV centre is a stable optical defect having a spin allowing high sensitive magnetic field detection with nanoscale resolution [1,2]. Nanodiamonds with NV centres can be use for the sensing of the protein ferritin, which keep iron (until 4500 iron atoms per one protein) in the blood to produce haemoglobin in further [3].

In our work we used a bulk diamond with shallow implant NV centres (3-5 nm from the surface). We attached ferritin to a silica particle, which was on the end of AFM tip. In this case one can choose the distance between the NV centre and proteins and measure changes of the relaxation times (T1 and T2) of NV.

Here, we present an image of relaxation times of NV*s spin as a function of the position of ferritin on AFM tip. We compare this with previous result [3] to determine the number of iron ions in the protein.

[1] G.Balasubramanian et al. Nature 455, 648-651 (2008); [2] J.M.Taylor, P.Capellaro et al., Nature Physics 4, 810*816 (2008); [3]A.Ermakova et. al., Nano Letters 13(7), 3305-3309 (2013)

MA 30.9 Wed 17:15 HSZ 403

Magnetic imaging using a scanning single qubit and optimal control — •Thomas Häberle[1], Dominik Schmid-Lorch[1], Khaled Karrai[2], Friedemann Reinhard[1], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut and Stuttgart Research Center of Photonic Engineering (SCoPE), Universität Stuttgart, Germany — [2]attocube systems AG, Munich, Germany

We present a novel scanning probe technique for magnetic field microscopy that promises a higher spatial resolution than standard MFM [1]. The new scanning probe is the nitrogen-vacancy (NV)-color center in diamond, which can be employed as an atom-sized magnetic field sensor by monitoring the Zeeman-shift of its spin sublevels [2-3].

I will present benchmark measurements on magnetic nanostructures, in particular a quantitative mapping of the field produced by an MFM-tip. These results were used to validate analytical models proposed for quantitative MFM [4]. Furthermore, I will explain the advanced spectroscopy protocol that was applied in the measurements. It is based on optimal control and enables fast acquisition of strongly varying magnetic field gradients with quantum-limited sensitivity [5].

[1] G. Balasubramanian et al., Nature Vol 455, 648-651 (2008)
[2] L. Rondin et al., Appl. Phys. Lett.. Vol. 100, 153118 (2012)
[3] P. Maletinsky et al., Nat. Nanotech. Vol. 7, 320-4 (2012)
[4] T. Häberle et al., New J. Phys. Vol. 14, 043044 (2012)
[5] T. Häberle et al., Phys. Rev. Lett. Vol. 111, 170801 (2013)

MA 30.10 Wed 17:30 HSZ 403

Synchronous precessional motion of multiple domain walls in a ferromagnetic nanowire by perpendicular field pulses — •Mohamad-Assaad Mawass[1,2], June-Seo Kim[1,3], Andre Bisig[1,2], Benjamin Krüger[1], Robert Reeve[1], Tomek Schulz[1], Felix Büttner[1,5], Jungbum Yoon[4], Chun-Yeol You[4], Markus Weigand[2], Hermann Stoll[2], Gisela Schütz[2], Henk J. M. Swagten[3], Bert Koopmans[3], Stefan Eisebitt[5], and Mathias Kläui[1] — [1]Johannes Gutenberg-Universität Mainz, Germany — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany — [3]Eindhoven University of Technology, The Netherlands — [4]Inha University, Republic of Korea — [5]Technische Universität Berlin

Magnetic storage and logic devices based on magnetic domain wall (DW) motion rely on the precise and synchronous displacement of multiple domains and DWs. The conventional approach using magnetic fields efficiently drives DWs but does not allow for the necessary synchronous motion of multiple domains. As an alternative method, synchronous current-induced DW motion has been studied, but the required high critical current densities prevent widespread use in devices. Here, we demonstrate a radically different approach: We use out-of-plane magnetic field pulses to move in-plane domains, thus combining the efficiency of field-induced magnetization dynamics with the ability to move neighbouring domains and DWs in the same direction. the displacement can be understood from the acting torques.

MA 30.11 Wed 17:45 HSZ 403

Non-contact bimodal Magnetic Force Microsopy — •Johannes Schwenk[1], Miguel Marioni[1], Niraj Joshi[1], Sara Romer[1], and Hans-Josef Hug[1,2] — [1]Empa, Swiss Federal Laboratories for Materials Science and Technology, CH-8600 Dübendorf, Switzerland. — [2]Department of Physics, University of Basel, CH-4056 Basel, Switzerland

We present a bimodal Magnetic Force Microscopy technique which is capable to reveal the magnetic stray field of a sample as well as the corresponding topography in a single pass scan. Being single pass makes the technique independet from all kinds of instrumental drift and allows to scan with lowest tip sample separation. Therefore it provides high lateral resolution since the tip interacts with low range magnetic stray fields of small magnetic features. The bimodal technique is suitable for vacuum conditions and stable for high Q and soft cantilevers that are necessary for high sensitivity measurements.

MA 31: Focus Session: Spin-Orbit Torque at Surfaces and Interfaces

Organizer: Y. Mokrousov (RWTH Aachen)

The phenomenon of the spin-orbit torque (SOT) is rapidly moving to the center of attention both in theoretical as well as applied spintronics. The principle of SOT relies on the spin-orbit interaction in combination with ferromagnetic magnetization and broken inversion symmetry, and it can be used to successfully switch the magnetization of a deposited collinear ferromagnetic layer with strong perpendicular anisotropy in an in-plane current geometry. Despite extensive experimental evidence of this effect, its origins are still intensively debated. In this session we want to focus on the foremost experimental achievements in the field of SOT, and on theoretical progress in understanding of the SOT and its description based on microscopic material theory.

Time: Wednesday 15:00–17:45 Location: BEY 118

Topical Talk MA 31.1 Wed 15:00 BEY 118
Magnetization switching and spin-orbit torques in AlOx/Co/Pt and MgO/CoFeB/Ta layers — •Pietro Gambardella — Department of Materials, ETH Zurich

Spin-orbit torques induced by spin Hall and Rashba-like effects in heavy metal/ferromagnetic bilayers allow for magnetization switching based on in-plane current injection. Using this geometry, we demonstrate deterministic magnetization reversal induced by sub-ns current pulses in 100 to 200 nm sized dots and discuss the switching efficiency as a function of pulse duration. Further, we present vector measurements of the longitudinal and transverse spin-orbit torques in AlOx/Co/Pt and MgO/CoFeB/Ta trilayers using harmonic analysis of the anomalous and planar Hall effects, providing evidence for strongly anisotropic field-like and spin transfer-like components that are compatible with the symmetry of the trilayers. The switching efficiency and relative magnitude of the longitudinal and transverse torques are analyzed in annealed MgO/CoFeB/Ta trilayers as a function of magnetization, magnetic anisotropy, and resistivity.

Topical Talk MA 31.2 Wed 15:30 BEY 118
Recent Theoretical Progress in Spin-orbit Torques — •Aurelien Manchon — Physical Science and Engineering Division, King Abdullah University of Science and Technology (KAUST), Thuwal 23955, Saudi Arabia

Utilizing spin-orbit coupling to enable the electrical manipulation of ferromagnets and magnetic textures has attracted a considerable amount of interest in the past few years. In a first part, I will introduce the most striking experimental achievements to date in bulk or interfacial inversion asymmetric systems. In a second part, I will present the most recent theoretical progress in the field, spanning from the role of intrinsic contributions to the spin-orbit torque to the impact of the newly predicted spin swapping effect. In a third part, I will introduce a new paradigm, coined spin-orbit caloritronics. Indeed, we recently demonstrated that even in the absence of magnetic texture, a magnon flow generates torques if magnons are subject to Dzyaloshinskii-Moriya interaction (DMI) just as an electron flow generates torques when submitted to Rashba interaction. We show that merging the spin-orbit torques with spin caloritronics is rendered possible by the emergence of DMI in magnetic materials and opens promising avenues in the development of chargeless information technology.

Topical Talk MA 31.3 Wed 16:00 BEY 118
Domain-wall depinning governed by the spin Hall effect — •Reinoud Lavrijsen, Bert Koopmans, Henk Swagten, Elena Mure, Jeroen Franken, and Pascal Haazen — Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands

Current induced domain wall motion (CIDWM) in perpendicular materials has caused much excitement over the last few year years due to the discovery of unexpected DW driving mechanisms. Recently, we have shown that the Spin Hall Effect (SHE) [1,2] provides a radically new mechanism for CIDWM in these systems [3]. Essential for this work was the ability to create and pin DWs at well-defined positions in a Pt/Co/Pt nanowire. By studying the depinning of these DW*s as function of applied field directions and current we were able to disentangle different contributions. This allows us to unambiguously identify the SHE as the driving mechanism.

In the first part of this talk we will discuss the SHE mechanism and introduce an DW depinning experiment that allows us to disentangle different contributions to CIDWM. In the second part of this talk we will discuss potential applications of the SHE for magnetization manipulation in gated heterostructures. Furthermore, we will discuss preliminary experiments where we study the effect of growth conditions on the SHE efficiency.

[1] I. M. Miron et al., Nature 476, 189 (2011) [2] L. Liu et al., Science 336, 555 (2012) [3] P.P.J. Haazen et al., Nature Materials, 12, 299-303 (2013

15 min. break

Topical Talk MA 31.4 Wed 16:45 BEY 118
The Spin Hall Effect and Spin Orbit Torques in Ferromagnetic/Normal Metal Nanostructures — •Robert Buhrman — Cornell University, Ithaca NY USA

In the spin Hall effect (SHE) the passage of a charge current through a non-ferromagnetic metal (NM) film generates a transverse spin current that when it impinges onto an adjacent ferromagnetic (FM) film will exert both a damping-like torque and a field-like torque on the FM, with the former arising from the absorption of the transverse component of the incident spin current and the latter due to spin rotation during the reflection of a portion of the incident spin current. Certain NMs (e.g. Pt, Ta, and W) have been found to exhibit a strong SHE and the damping-like torque that can be exerted in this manner on thin film magnetic materials has significant potential for spintronics in that it has been demonstrated to be capable of reversibly switching the magnetization direction of both in-plane and out-of-plane magnetized nanomagnets, to induce persistent microwave magnetic oscillations, and to facilitate the high-speed manipulation of domain walls in magnetic nanostrips. I will report some recent results from our SHE studies, including investigations into the fundamental role that the interfacial spin-mixing conductance plays in determining the effectiveness of the SHE for exerting strong anti-damping spin torques on the adjacent ferromagnet and experiments which demonstrate that both the damping-like torque and the field-like torque arise from the *bulk* SHE.

Topical Talk MA 31.5 Wed 17:15 BEY 118
Spin-orbit torques from first principles — •Frank Freimuth — Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Under application of electric currents, ferromagnetic (FM) layers asymmetrically sandwiched between nonmagnets (NM1, NM2) in NM1/FM/NM2 films are subject to spin-orbit torques (SOTs), which can serve to switch magnetization. Using density-functional theory calculations we study SOTs within the Kubo linear response formalism [1]. Comparing SOTs in NM1/FM films for different choices of NM1 (Pt, W, Ta, Ir, Ru, Au) we show that the sign of the spin Hall effect in these transition metals correlates with the even ("damping-like") component of SOT. Resolving torques and spin-fluxes on the atomic scale allows us to elucidate further the role of spin-currents in mediating the SOTs and to identify an additional spin-current independent component. Varying the thickness of Co and the choice of NM2 in NM2/Co/Pt(111) films we find a strong sensitivity of the odd ("field-like") component of SOT, while the even component is less sensitive. Estimating extrinsic contributions from a scalar disorder model [2] we argue that intrinsic effects prevail. We relate the intrinsic even SOT to the Dzyaloshinskii-Moriya interaction [3,4] and show that the intrinsic even SOT can be driven also by temperature gradients instead of electric currents.

[1] F. Freimuth et al., arXiv:1305.4873 [2] J. Weischenberg et al.,

PRL **107**, 106601 (2011) [3] F. Freimuth et al., arXiv:1308.5983 [4] F. Freimuth et al., arXiv:1307.8085

MA 32: Invited Talk - Heidemarie Schmidt (Joint Session with DF, HL, DS, KR)

Time: Wednesday 15:00–15:45 Location: GER 37

Invited Talk MA 32.1 Wed 15:00 GER 37

Smart multiferroic thin films for cognitive computing — •Heidemarie Schmidt — Technische Universität Chemnitz, Department of Materials for Nanoelectronics, Reichenhainer Str. 39, 09126 Chemnitz

Cognitive systems promise to penetrate complexity and assist people and organizations in better decision making [1]. We have successfully prepared metal-multiferroic-metal (MMM) structures with the multiferroic material BiFeO3 and BiFeTiO3. All those MMM structures exhibit nonvolatile resistive (meristive) switching. Investigations of memristive switching is driven by promising applications of power-efficient memristive nanostructures including data storage, logic systems, cognitive computing and artificial neural networks. Prominence of work on memristive systems might be visualized by the near-future breakthrough in computing technology, where classical Von Neumann architecture is replaced by cognitive systems. In this talk I present three new functionalities of smart MMM structures including nonvolatile multilevel resistive switching [2], nonvolatile reconfigurable logics and nonvolatile second and higher harmonics generation [3] which are very promising for the development of cognitive computing. [1] J. E. Kelly III, S. Hamm, Smart Machines: IBM*s Watson and the Era of Cognitive Computing, Columbia University Press, 2013 [2] Y. Shuai et al., J. Appl. Phys. 109 (2011); Appl. Phys. Lett. 98 (2011); Appl. Phys. Exp. 4 (2011); 111 (2012); IEEE Electron Device Letters 34 (2013); Scientific Reports 3 (2013) [3] N. Du et al., Rev. Sci. Instr. 84 (2013)

MA 33: Quantum information systems I (with HL/TT)

Time: Wednesday 15:00–16:30 Location: POT 006

MA 33.1 Wed 15:00 POT 006

Improving the efficiency of passive Hall effect circulator — •Giovanni Viola[1] and David DiVincenzo[1,2] — [1]Institute for Quantum Information , RWTH Aachen — [2]Department of Theoretical Nanoelectronics, Peter Gruenberg Institute, Forschungszentrum Juelich

Low temperature microwave technology and the implementation of quantum computation require circulators as building blocks. Three-port circulators are examples of non-reciprocal devices; they should be passive, low noise and must operate at and below microwave frequencies. It is known that the Hall effect in the quantum regime shows non reciprocal behavior, and it can be utilized in a straightforward way in the realization of highly lossy circulators as well as gyrators. We have analyzed the physical origin of this lossy behaviour and, based on this understanding, developed a novel device that improves efficiency by dealing with the galvanic loss of the earlier designs. These novel circulators and gyrators are particularly suitable for current experiments: they are characterized by low loss and should be suitable for low temperature operation.

MA 33.2 Wed 15:15 POT 006

Large-scale density functional theory study of localization of donor electrons in phosphorus-doped silicon — •Pengxiang Xu[1], Elias Rabel[2], Wei Zhang[1], Riccardo Mazzarello[1], Rudolf Zeller[2], and Stefan Blügel[2] — [1]Institute for Theoretical Solid State Physics, RWTH Aachen, 52074 Aachen, Germany — [2]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The spin of an electron bound to a Phosphorus impurity in lightly Phosphorus-doped Silicon is a promising system for the realization of a spin quantum bit. By using two highly scalable density functional theory codes, KKRnano and QUICKSTEP, we investigate the structural and electronic properties of large models of P-doped Si containing up to 10^4 atoms, focusing in particular on those properties which are relevant to their application as spin qubits.

Computation of the electronic structure of a P impurity as a function of the isotropic doping fraction enable us to determine the doping potential, the doping density and the exchange interaction between donor electrons up to inter-impurity distances of approximately six nanometers.

Our density functional calculations reveal details in the density and potential distribution of the dopants, which are not evident in calculations that do not include explicit treatment of the P donor atom and the relaxation of the crystal lattice.

MA 33.3 Wed 15:30 POT 006

Deterministic Entanglement of Distant Nitrogen Vacancy Centers on an Integrated Photonic Platform — •Janik Wolters[1], Julia Kabuss[2], Andreas Knorr[2], and Oliver Benson[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Nano-Optik, Newtonstraße 15, 12489 Berlin — [2]Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin

The nitrogen vacancy (NV) defect center in diamond has emerged as one of the most promising candidates for future solid state quantum technology. In particular recent progress on the integration of NV centers into photonic hybrid platforms attracted attention [1]. We explore the prospects of such an integrated quantum hybrid platform. The applicability of a robust, fast and deterministic entanglement scheme [2] is evaluated. Using realistic conditions and parameters (cavity quality factors, radiative dephasing and spectral diffusion) we find that significant entanglement can be generated between medium distant NV centers via a shared cavity mode. These studies outline a route towards deterministic quantum information processing on a realistic solid state platform.

[1] Wolters, J. et al. Enhancement of the zero phonon line emission from a single nitrogen vacancy center in a nanodiamond via coupling to a photonic crystal cavity. Appl. Phys. Lett. 97, 141108 (2010).

[2] Imamoglu, A. et al. Quantum Information Processing Using Quantum Dot Spins and Cavity QED. Phys. Rev. Lett. 83, 4204 (1999).

MA 33.4 Wed 15:45 POT 006

Interaction between differently charged states of the nitrogen vacancy in diamond — •Dion Braukmann[1], J. Debus[1], D. Dunker[1], V. Yu. Ivanov[2], D. R. Yakovlev[1], and M. Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]Institute of Physics, Polish Academy of Sciences, 02668 Warsaw, Poland

The nitrogen vacancy (NV) in diamond is studied on account of its possible applications in spin-electronics. Temperature-stable properties are ranked among the main advantages of the NV center: Even at room temperature spin coherence times exceed one second.[1] The NV center appears in differently charged states. About 70% are negatively charged (NV^-), the rest are neutral (NV^0) centers. In contrast to the NV^-, the NV^0 is poorly investigated. For single NV centers it was shown that both charge states can transform into each other. In that context, an ensemble of NV centers has not been studied yet. We report on polarization-dependent optical characterization of ensembles of NV^- and NV^0 centers in diamond subjected to high magnetic fields, thus providing insight into their level structures. The talk will be focused on interactions between both charged states. We observe a strong increase in NV^- ZPL intensity and a characteristic resonance of the NV^- ZPL energy when the NV^0 center is excited resonantly. This behavior can either be explained by a change in the charge state or by a Förster resonant energy transfer. Both possibilities will be discussed in detail.

[1] P. C. Maurer et al., Science, 336, 1283 (2012).

MA 33.5 Wed 16:00 POT 006

Few spin NMR of external spins using a strongly coupled sensor in diamond — •Christoph Müller[1], Xi Kong[2], Jiangming Cai[3], Kristina Melentijević[1], Alastair Stacey[4], Matthew Markham[4], Daniel Twitchen[4], Junichi Isoya[5], Sébastien Pezzagna[6], Jan Meijer[6], Jiangfeng Du[2], Martin Plenio[3], Boris Naydenov[1], Liam McGuinness[1], and Fedor Jelezko[1] — [1]Institute for Quantum Optics, University Ulm, Germany — [2]Hefei National Laboratory for Physics Sciences at Microscale and Depatment of Modern Physics, University of Science and Technology of China, Hefei, China — [3]Institute for Theoretical Physics, University Ulm, Germany — [4]Element Six, Ltd, Ascot, Berkshire, United Kingdom — [5]Research Center for Knowledge Communities, University of Tsukuba, Ibakiri, Japan — [6]Experimental Physics II, University Leipzig, Germany

Negatively charged nitrogen-vacancy (NV^-) centres in diamond, located around 2 nm below the diamond surface were used as a NMR sensor at room-temperature. Strong coupling between the electron spin of the NV^- centre and external nuclear ^{29}Si spins on the diamond surface made it possible to measure the NMR signal aroused by four nuclear spins. With the achieved signal to noise ratio, single spin sensitivity within seconds is possible. In addition, the field gradient created by the NV^- centre itself combined with compressed sensing enables to locate the detected individual nuclei with Angstrom resolution.

MA 33.6 Wed 16:15 POT 006

Increasing the creation yield of shallow nitrogen-vacancy centers by surface plasma termination — •Christian Osterkamp[1], Jochen Scharpf[1], Sebastien Pezzagna[2], Jan Meijer[2], Thomas Diemant[3], Rolf Jürgen Behm[3], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Ulm University, Albert Einstein Allee 11, 89081 Ulm, Germany. — [2]Institut für Experimentelle Physik II, Abteilung Nukleare Festkörperphysik, Universität Leipzig, Linnestraße 5, 04103 Leipzig, Germany. — [3]Institut für Oberflächenchemie und Katalyse, Ulm University, Albert-Einstein-Allee 47, 89081 Ulm, Germany.

Single nitrogen-vacancy (NV) centers in diamond close to the crystal surface are very promising magnetic field sensors with very high sensitivity and nanometer spacial resolution. The fluorescence of single NVs can be detected and its electron spin can be polarized, read-out and manipulated at ambient conditions. Here we report the enhanced creation of very shallow (less than 3 nm below the diamond surface) NVs by using fluorine and oxygen plasma treatment. We observe a four fold increase - from 0.11 % to about 0.45 % in the production yield when the sample surface is terminated with fluorine or oxygen atoms [1]. This effect is explained by the stabilization of the NV's negative charge state which is influenced by the various impurities present on the diamond surface.

[1]: Osterkamp et al., Appl. Phys. Lett. 103 (19), S.193118. (2013)

MA 34: Posters: Graphene (with DY/DS/HL/O/TT)

Time: Wednesday 17:00–20:00 Location: P1

MA 34.1 Wed 17:00 P1

Semi-empirical phonon calculations for graphene on different substrates — •Henrique Miranda, Alejandro Molina-Sanchez, and Ludger Wirtz — Physics and Materials Science Research Unit, UNIVERSITÉ DU LUXEMBOURG, Luxembourg

We investigate the graphene-substrate interaction via changes in the phonon dispersion of graphene. Ab-initio calculations on these systems are of high computational cost due to the non-commensurability of the unit cells of graphene and the substrate. This leads to the formation of Moiré patterns with accordingly large supercell sizes. We use a semi-empirical force constant model for the calculation of phonons of graphene on different metallic and insulating substrates. The interaction of graphene with the substrate is described via suitably chosen spring constants. The phonon dispersion in the primitive unit cell of graphene is obtained via an "unfolding procedure" similar to the ones used for the discussion of ARPES (angular resolved photo-emission spectroscopy) of graphene on incommensurate substrates.

MA 34.2 Wed 17:00 P1

Bilayer graphene: topological phases and entanglement spectrum — •Sonja Predin and John Schliemann — Institute for Theoretical Physics,University of Regensburg, D-93040 Regensburg, Germany

We present a calculation of the entanglement spectrum of fermions in bilayer graphene. In particular, a non-trivial topological order of the Abelian phase of the time-reversal symmetry breaking d-wave state is studied. We show that the entanglement spectrum is gapped, additionally we show that edge excitations in the entanglement spectrum form doublet Dirac fields around every K point.

MA 34.3 Wed 17:00 P1

Ultrafast dynamics and photoluminescence of hot carriers in graphene — •Thomas Danz, Andreas Neff, Reiner Bormann, Sascha Schäfer, and Claus Ropers — IV. Physical Institute, University of Göttingen, 37077 Göttingen, Germany

The ultrafast dynamics of optically excited carriers in graphene can be monitored by pump-probe spectroscopy [1,2]. Furthermore, it was recently shown that the thermalization of hot carriers leads to photoluminescence at wavelengths far away from the exciting pump [3,4]. Here, we present the implementation of an experimental setup which combines transient spectroscopy with sub-15-fs temporal resolution with hot carrier photoluminescence detection under the same excitation conditions. With this approach, we aim at a comprehensive picture of the ultrafast carrier response and the disentanglement of the timescales underlying different relaxation pathways. First experimental results will be presented.

[1] J. M. Dawlaty *et al.*, Appl. Phys. Lett. **92**, 042116 (2008)
[2] M. Breusing *et al.*, Phys. Rev. B. **83**, 153410 (2011)
[3] C. H. Lui *et al.*, Phys. Rev. Lett. **105**, 127404 (2010)
[4] W. Liu *et al.*, Phys. Rev. B. **82**, 081408 (2010)

MA 34.4 Wed 17:00 P1

Electron spin resonance of ion-irradiation induced single vacancies on monolayer graphene characterized by scanning tunneling spectroscopy — •Sven Just[1], Stephan Zimmermann[2], Vladislav Kataev[2], Marco Pratzer[1], Bernd Büchner[2], and Markus Morgenstern[1] — [1]II. Physikalisches Institut B, RWTH Aachen — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden

Single vacancies with densities of 0.003/nm^2 − 3/nm^2 are prepared on HOPG and on single layer graphene on SiO_2 produced by chemical vapour deposition using Ar ions with 50 eV kinetic energy. The vacancies exhibit a peak at E_F in scanning tunneling spectroscopy, which survives 3 h of air exposure, afterwards a small broadening of the peak is observed. Electron spin resonance shows a peak corresponding to g = 2.0022, if the defect density is above 0.3/nm^2, and a peak width of 10 G with an anisotropy below 0.5 G between in-plane and out-of-plane magnetic field. The peak width hardly depends on temperature, while the peak intensity decreases with increasing temperature in the range of 4 K - 20 K.

MA 34.5 Wed 17:00 P1

Enhancing the Raman signal of graphene on SiC(0001) by using a solid immersion lens in *top-down* geometry — •Felix Fromm[1], Martin Hundhausen[2], Michl Kaiser[3], Julia Krone[1], and Thomas Seyller[1] — [1]TU Chemnitz, Institut für Physik — [2]FAU Erlangen-Nürnberg, Lehrstuhl für Laserphysik — [3]FAU Erlangen-Nürnberg, Lehrstuhl für Werkstoffwissenschaften

We present a study of epitaxial graphene by recording Raman spectra from the backside through the silicon carbide (SiC) substrate. In that *top-down* geometry we profit from the fact, that the graphene layer emits approximately 96 % of the Raman intensity into the SiC [1]. However, we only observe an intensity enhancement of approximately a factor of 4 compared to the conventional *top-up* geometry. This is because the solid angle of detection is decreased by refraction at the SiC/air interface and is limited by the total internal reflection. To further improve the detection efficiency, we use a high refractive index solid immersion lens (SIL) made of cubic zirconia combined with a suitable immersion liquid. By that, the angle of total internal reflection, as well as the solid angle of detection are increased. We eventually observe an increase of the detected Raman intensity towards the *top-up* geometry to a factor of 25. As an additional advantage, the background signal of the two-phonon Raman modes of the SiC is suppressed to a large extent.

[1] F. Fromm et al., New J. Phys. 15, 113006 (2013)

MA 34.6 Wed 17:00 P1

Growth of graphene on 6H-SiC(0001) under ammonia/argon atmosphere — •Christian Raidel, Felix Fromm, Samir Mammadov, Martina Wanke, and Thomas Seyller — TU Chemnitz, Insitut für Physik, Germany

In this work we investigated the nitrogen incorporation into epitaxial grown monolayer graphene by using ammonia as process gas within argon flow during thermal decomposition of SiC. The growth parameters as temperature and ammonia concentration were studied by various surface sensitive methods as XPS, LEED, RAMAN, AFM, and STM. ARPES shows that the ammonia grown graphene shows more p-type doped graphene than undoped graphene on SiC(0001). Due to the dissociation of ammonia during the growth process etch pits are produced. Vacancy associated nitrogen incorporation was observed by XPS and STM.

MA 34.7 Wed 17:00 P1

Characterization and transfer of 2D dichalcogenides produced by anodic bonding — •Philipp Nagler, Gerd Plechinger, Christian Schüller, and Tobias Korn — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

Atomically thin MoS_2 and WS_2 structures have attracted growing attention as promising 2D semiconductors. As monolayers, both materials exhibit a direct bandgap and therefore are suitable candidates for future opto-electronical devices. We produced singlelayer MoS_2 and WS_2 by means of anodic bonding. In this process, the material is bonded by electrostatic forces on a borosilicate glass substrate. Compared to mechanical exfoliation, this technique usually yields larger flakes. Anodic bonded MoS_2 flakes were characterized by Raman and photoluminescence (PL) spectroscopy. Performing low-temperature PL measurements, we observed similar behaviour as in SiO_2-supported MoS_2. Furthermore, PL measurements for anodic bonded WS_2 are presented. By applying the wedging transfer technique, we transferred anodic bonded monolayer WS_2 from the glass to a SiO_2 substrate. Additionally, using this method, heterostructures consisting of various 2D materials could be produced and characterized.

MA 34.8 Wed 17:00 P1

Graphene nanostructures produced from transfered layers — •Christopher Belke, Dmitri Smirnov, Johannes C. Rode, Hennrik Schmidt, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, D-30167 Hannover, Germany

Graphene consists of carbon atoms, which are arranged in a two-dimensional honeycomb lattice. It has unique electronic properties, which can be examined in high quality samples [1]. These are often prepared by mechanical exfoliation on a silicon wafer with silicon dioxide on top. This substrate has a strong influence on the transport properties due to charge traps and surface roughness [2]. To reduce these effects or to produce novel complexe layersystems, graphene sheets can be stacked by a transfer methode e. g. onto other substrates or one upon the other to fabricate twisted flakes. The latter has been done and was under examination with magnetotransport measurements.
Graphene is exfoliated on a thin PMMA layer, which can be detached from the silicon wafer. This layer is then placed on another graphene mono- or bilayer flakes. The samples were characterized at low temperatures and in dependence of a magnetic field. Magnetic field independent oscillations could be observed in a multilayer system.

[1] K. S. Novoselov et al. Science **306**, 666 (2004)
[2] P. Barthold et al. NJP **13**, 0433020 (2011)

MA 34.9 Wed 17:00 P1

Twisted graphene bilayers, folded via atomic force microscope — •Johannes C. Rode, Dmitri Smirnov, Christopher Belke, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover

Naturally occurring double-layer graphene consists of two hexagonal lattices in Bernal stacking. We investigate the folding of single-layer graphene via atomic force microscope (AFM) and the electronic properties of thusly created bilayers. The crystal lattices of these are twisted against each other which affects the interlayer coupling, giving rise to interesting electronic properties like a screening effect and reduced Fermi velocities at higher twist angles. Furthermore, the influence of a moiré-superlattice or twist induced van-Hove-singularities can be expected at lower twist angles. Our samples are obtained by micromechanical cleavage of natural graphite and placed on a silicon substrate with a top layer of silicon dioxide. The atomic force microscope then serves as a tool to mechanically manipulate the sample by programmed tip movements. We show AFM-induced folding of graphene on a μm-scale which can afterwards be contacted via e-beam lithography. Magnetotransport measurements over the folded areas show interesting signatures like multiple origins of landau fans in the charge carrier concentration.

MA 34.10 Wed 17:00 P1

The Effect of the Chemical Potential of Graphene on THz Detection — •Markus Göthlich[1], Fathi Gouider[1], André Müller[2], Yuri B. Vasilyev[3], and Georg Nachtwei[1] — [1]Institut für Angewandte Physik, Technische Universität Braunschweig, Mendelssohnstraße 2, D-38106 Braunschweig — [2]Physikalisch Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig — [3]A.F.Ioffe Physical Technical Institute, RU-194021 St.Petersburg, Russia

One particular fact about graphene is its remarkable Landau quantization $E_n = \mathrm{sgn}(n)\sqrt{\Delta^2 + 2\hbar e v_F^2 |n| B}$ with n being the Landau level (LL) index. This would allow a transition at 2.4 THz (corresponding to an energy of about 10 meV) to happen at a magnetic field as low as 0.2 T. But theoretical investigations show the opening of a bandgap and a high chemical potential in epitaxial graphene on Si-face SiC due to graphene–substrate interactions. On the other hand our calculations—based on Gusynin et al. Phys. Rev. Lett. 98, 157402 (2007)—show that at high chemical potential the photoresponse can only be observed at higher magnetic fields of some Tesla. Gating is difficult due to the insolating behaviour of SiC substrate on the one hand and THz intransparency of top gates on the other hand. Therefore our aim is to design a new sample geometry that allows the manipulation of the chemical potential of the graphene while not blocking the THz radiation before reaching the detector.

MA 34.11 Wed 17:00 P1

Gate-controlled STM study of magnetic impurities on a graphene surface — •Paul Punke[1], Christian Dette[1], Roberto Urcuyo[1], Christopher Kley[1], Sören Krotzky[1], Rico Gutzler[1], Marko Burghard[1], Soon Jung Jung[1], and Klaus Kern[1,2] — [1]Max-Planck-Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany — [2]Institut de Physique de la Matière Condensée, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

Graphene has been regarded as an ideal material for post silicon electronic application due to its unique electronic properties. To realize a field effect transistor for logic applications out of graphene, there has been a lot of effort to understand the gating effect on the charge-carrier-density-dependent properties of graphene, such as electronic scattering, spin based phenomena and collective excitations. We have designed a gatable low temperature scanning tunneling microscope (STM) by adding contacts to the sample holder. To prepare the gate-tunable graphene devices, we use graphene grown by chemical vapor deposition (CVD), transferred with or without a supporting layer of polymethylmethacrylate (PMMA) or polystyrene (PS), on an insulating layer of SiO2 or hexagonal boron nitride (h-BN) on SiO2. We also grow the graphene on h-BN directly on Ni substrate by CVD method. The quality of these samples will be compared by means of optical microscopy, atomic force microscopy (AFM), Raman spectroscopy and STM. Finally, we will present the gate-controlled electronic structure of graphene.

MA 34.12 Wed 17:00 P1

Ion Implantation of Graphene - Toward IC Compatible Technologies — •H. Hofsäss[1], U. Bangert[2,3], W. Pierce[2], D. M. Kepaptsoglou[3], Q Ramasse[3], R Zan[1], M. H. Gass[3,4], J.A. van den Berg[5], C. Boothroyd[6], and J Amani[1] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, Göettingen, Germany — [2]School of Materials, The University of Manchester, Manchester, United Kingdom — [3]SuperSTEM Laboratory, Daresbury, United Kingdom — [4]AMEC, Walton House, 404 The Quadrant, Birchwood, United Kingdom — [5]School of Computing, Science and Engineering, University of Salford, Salford, United Kingdom — [6]Ernst Ruska-Centre for Microscopy and Spectroscopy, Juelich Research Centre, Juelich, Germany

Doping of graphene via ultra low energy ion implantation could open possibilities for fabrication of nanometer-scale patterned graphene-based devices as well as for graphene functionalization compatible with large-scale integrated semiconductor technology. Using advanced electron microscopy/spectroscopy methods, we show for the first time directly that graphene can be doped with B and N via ion implantation of mass selected ions at energies of 20 - 30 eV and that the retention is in good agreement with predictions from calculation-based literature values. Atomic resolution high-angle dark field imaging (HAADF) combined with single-atom electron energy loss (EEL) spectroscopy reveals that for sufficiently low implantation energies ions are predominantly substitutionally incorporated into the graphene lattice with a very small fraction residing in defect-related sites.

MA 35: Mitgliederversammlung des Fachverbandes Magnetismus (MA)

Time: Wednesday 18:15–19:45 Location: HSZ 04

Berichte und Anfragen

MA 36: Spincaloric Transport II (jointly with TT)

Time: Thursday 9:30–12:15 Location: HSZ 04

MA 36.1 Thu 9:30 HSZ 04

6000 % tunnel magneto-Seebeck effect under applied bias — •Alexander Boehnke[1], Marius Minikel[2], Marvin Walter[2], Vladylsav Zbarsky[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. Physikalisches Institut, Georg-August-Universität Göttingen, Germany

Recently, significantly different values of the tunnel magneto-Seebeck effect (TMS) [1-5] have been reported when the material system of the magnetic tunnel junction (MTJ) is changed. Ab initio calculations shine first light on the origin of these differences, as they propose a strong influence of the lead material on the TMS [6]. We applied an additional bias voltage V_{Bias} to MTJs while measuring the TMS.

This well-defined tuning of the electrodes' Fermi level positions allows to compare the bias voltage dependence of the TMS with the theoretical predictions. We demonstrate drastically changing TMS ratios of up to 6000 % generated by the variation of the bias voltage. At certain values of V_{Bias}, an on/off behavior of the Seebeck voltage is found when the magnetization alignment of an MTJ is reversed. These findings are in good agreement with the ab into calculations [6].

[1] M. Walter et al. (2011). Nat. Mater., 10(10), 742.
[2] N. Liebing et al. (2011). Phys. Rev. Lett., 107(17), 177201.
[3] W. Lin et al. (2012). Nat. Commun., 3, 744.
[4] N. Liebing et al. (2013). Appl. Phys. Lett., 102(24), 242413.
[5] A. Boehnke et al. (2013). Rev. Sci. Instrum., 84(6), 063905.
[6] C. Heiliger et al. (2013). Phys. Rev. B, 87(22), 224412.

MA 36.2 Thu 9:45 HSZ 04

Thin film studies of the spin Seebeck effect in insulating ferrimagnets — •Andreas Kehlberger[1], Gerhard Jakob[1], Ulrike Ritzmann[2], Denise Hinzke[2], Ulrich Nowak[2], Mehmet Onbasil[3], Dong Hun Kim[3], Caroline A. Ross[3], Matthias Benjamin Jungfleisch[4], Burkard Hillebrands[4], and Mathias Kläui[1] — [1]University of Mainz, D-55099 Mainz — [2]University of Konstanz, D-78457 Konstanz — [3]Massachusetts Institute of Technology, USA MA-02139 — [4]Technische Universität Kaiserslautern, D-67663 Kaiserslautern

One of the most basic and still unresolved questions is the origin of the spin-Seebeck effect (SSE) in magnetic insulators. Recent studies focused on the investigation of the dependence of the SSE on material parameters in bulk material [1], while for applications thin films are more appropriated. We study the longitudinal SSE (LSSE) in thin film garnets grown by PLD, which allows us to probe the dependence of the SSE on magnetic material parameters as well as on the thickness of the ferromagnetic material, revealing a relevant length scale for the LSSE in the order of 100 nm in YIG. A comparison with the magnetoresistance allows us to estimate its contributions and to identify the genuine origin of the SSE in the bulk of the YIG [2]. Beyond YIG, we study other garnets at variable temperatures to determine the SSE dependence on the dominating sub-lattice that governs the effective magnetic moment in a ferrimagnet [3]. [1] K. Uchida et al., Phys. Rev. B 87, 104412 (2013) [2] A. Kehlberger et al., arXiv:1306.0784 (2013) [3] Y. Ohnuma et al., Phys. Rev. B 87, 014423 (2013)

MA 36.3 Thu 10:00 HSZ 04

Magnonic spin currents and the spin Seebeck effect — •Ulrike Ritzmann, Denise Hinzke, and Ulrich Nowak — Universität Konstanz

In ferromagnetic insulators spatial temperature gradients can lead to a magnon accumulation [1]. Furthermore, it was shown that the measured voltage of the longitudinal spin Seebeck effect increases with film thicknes, saturating on a characteristic length scale [2].

We perform atomistic spin model simulation with the stochastic Landau-Lifshitz-Gilbert equation to investigate the relevant length scales for magnon accumulation. Supported by an analytical description we first calculate the characteristic length scale of magnon propagation in the vicinity of a temperature step [3]. Then we explore magnon propagation in a linear temperature gradient and determine the mean propagation length of the magnons [2]. Our main finding is that the magnon accumulation at the cold end of the temperature gradient first increases with the the length scale of the temperature gradient and then saturates when reaching the length scale of the magnon propagation. These results can explain the saturation of the longitudinal spin Seebeck effect [2] and can help to understand recent measurements regarding the temporal evolution of the spin Seebeck effect [4].

[1] K. Uchida et al, Nat. Mater. 9, 894 (2010)
[2] A. Kehlberger et al.,arXiv:1306.0784
[3] U. Ritzmann et al., submitted
[4] M. Agrawal et al., arXiv:1309.2164

MA 36.4 Thu 10:15 HSZ 04

Temporal evolution of the longitudinal spin Seebeck effect — •Vitaliy Vasyuchka[1], Milan Agrawal[1,2], Alexander Serga[1], Akihiro Kirihara[1,3], Philipp Pirro[1], Thomas Langner[1], Frank Heussner[1], Benjamin Jungfleisch[1], Andrii Chumak[1], Evangelos Papaioannou[1], and Burkard Hillebrands[1] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz — [3]Smart Energy Research Laboratories, NEC Corporation, Tsukuba, Japan

The spin Seebeck effect (SSE) is one of the most fascinating phenomena in the contemporary period of spin caloritronics. Further advancements in industrial applications like temperature gradient sensors and thermal spin-current generators require an in-depth understanding of this effect. We developed an experimental approach where we studied the temporal evolution of the SSE in YIG/Pt bilayer structures in the longitudinal configuration. Our findings reveal that this effect is a submicrosecond fast phenomenon governed by the temperature gradient and the thermal magnons diffusion in the magnetic material. A comparison of our experimental results with the thermal-driven magnon-diffusion model shows that the temporal behavior of the SSE depends on the time development of the temperature gradient in the vicinity of the YIG/Pt interface. The effective thermal-magnon diffusion length for our YIG/Pt system is estimated to be around 500 nm.

Financial support by the Deutsche Forschungsgemeinschaft (SE 1771/4-1) within Priority Program 1538 "Spin Caloric Transport" is gratefully acknowledged.

MA 36.5 Thu 10:30 HSZ 04

Thermally driven domain wall motion — •Frank Schlickeiser, Ulrike Ritzmann, Denise Hinzke, and Ulrich Nowak — University Konstanz, 78457 Konstanz, Germany

The existence of thermally driven domain wall (DW) motion caused solely by magnonic spin currents was forecast on the basis of computer simulations [1]. Recently, this effect has been measured in a magnetic insulator [2]. A deeper understanding of this effect is of great interest, since it potentially opens the door for new ways to control and manipulate domain structures in spintronic devices.

We present an analytical calculation of the DW velocity as well as the Walker threshold within the framework of the Landau Lifshitz Bloch equation [3] describing the dynamics of the thermally averaged spin polarization on micromagnetic length scales. We demonstrate analytically that the temperature gradient leads effectively to a spin transfer torque where the domain wall is mainly driven by the temperature dependence of the exchange stiffness, or — in a more general picture — by the maximization of entropy. We find a linear dependence of the averaged DW velocity on the temperature gradient in agreement with the experiment [2]. The approximations in our analytical calculation are verified by numerical simulations.

We acknowledge financial support by the DFG through SFB 767.

References: [1] D. Hinzke and U. Nowak, Phys. Rev. Lett. 107, 027205 (2011), [2] W. Jiang et al., Phys. Rev. Lett. 110, 177202 (2013), [3] D. A. Garanin, Phys. Rev. B 55, 3050 (1997).

15 min. break

MA 36.6 Thu 11:00 HSZ 04

Spin disorder effect on the spin-caloric transport properties in magnetic nanostructures from first principles — •Roman Kováčik, Phivos Mavropoulos, Daniel Wortmann, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

An important contribution to the thermoelectric and spin-caloric transport properties in magnetic materials at elevated temperatures is the formation of a spin-disordered state due to the local moment fluctuations. This effect has not been largely investigated so far. We focus on various magnetic nanostructures, motivated by the miniaturization of spintronics devices and by recent suggestions that magnetic nanostructures can lead to extraordinary thermoelectric effects due to quantum confinement [1]. The electronic structure of the studied systems is calculated within the multiple scattering screened Korringa-Kohn-Rostoker Green function (KKR-GF) framework [2]. The Monte-Carlo methodology is used to simulate the effect of temperature induced spin disorder and the transport properties are evaluated from the transmission probability obtained using the Landauer-Büttiker approach for the ballistic transport within the KKR-GF framework [3]. We find qualitative and quantitative changes in the thermoelectric and spin-caloric coefficients in the case that spin-disorder is included in the calculation. Support from the DFG (SPP 1538) is gratefully acknowledged.

[1] N. Vu *et al.*, APEX 4, 015203 (2011).
[2] N. Papanikolaou *et al.*, JPCM 14, 2799 (2002), also see: kkr-gf.org.
[3] Ph. Mavropoulos *et al.*, PRB 69, 125104 (2004).

MA 36.7 Thu 11:15 HSZ 04

Spin caloric transport in alloys from first-principles — •Sebastian Wimmer, Diemo Ködderitzsch, Kristina Chadova, and Hubert Ebert — Ludwig-Maximilians-Universität, München, Deutschland

A fully relativistic implementation of the Korringa-Kohn-Rostoker coherent potential approximation (KKR-CPA) band structure method [1] in conjunction with Kubo's linear response theory is employed to investigate various transport properties of bulk transition metal alloys. Special emphasis is put on spin-orbit coupling induced phenomena of thermo(-magneto)-electric transport in para- as well as ferromagnetic systems such as spin and anomalous Nernst effects and the anisotropy of the Seebeck effect [2,3]. These transverse and longitudinal responses to a temperature gradient are compared to their respective (magneto-)electric counterparts, the spin and anomalous Hall effects and the anisotropic magnetoresistance. For the transverse effects a decomposition into intrinsic and extrinsic (skew scattering and side-jump) contributions is performed, based on vertex corrections and scaling laws.

[1] H. Ebert, D. Ködderitzsch, and J. Minár, Rep. Prog. Phys. **74**, 096501 (2011).
[2] S. Wimmer, D. Ködderitzsch, K. Chadova, and H. Ebert, PRB **88**, 201108(R) (2013).
[3] S. Wimmer, D. Ködderitzsch, and H. Ebert, arXiv:1311.2498 [cond-mat.mtrl-sci] (2013).

MA 36.8 Thu 11:30 HSZ 04

Static proximity investigations on Pt/$NiFe_2O_4$ and Pt/Fe bilayers using x-ray resonant magnetic reflectivity — •Timo Kuschel[1], Christoph Klewe[1], Jan-Michael Schmalhorst[1], Florian Bertram[2], Olga Schuckmann[3], Tobias Schemme[3], Joachim Wollschläger[3], Arunava Gupta[4], Gerhard Götz[1], Daniel Meier[1], and Günter Reiss[1] — [1]Bielefeld University, Germany — [2]Lund University, Sweden — [3]Osnabrück University, Germany — [4]University of Alabama, Tuscaloosa Alabama, USA

When Pt is used to detect spin currents in an attached magnetic film via the inverse spin Hall effect, parasitic charge based effects can be induced due to spin polarization in Pt generated by static proximity. For example, in spin caloritronics the anomalous Nernst effect (ANE) can contribute to the longitudinal spin Seebeck effect (LSSE) signal when an out-of-plane temperature gradient is applied. In case of Pt/YIG Lu et al. [1] observed a spin polarization in Pt via XMCD, while Geprägs et al. [2] found no evidence for static proximity in Pt/YIG. Recently, we have observed the LSSE in $NiFe_2O_4$ (NFO) thin films [3]. Now, we used x-ray resonant magnetic reflectivity (XRMR) to exclude the ANE. XRMR is interface sensitive and therefore, mainly independent of the Pt thickness, which makes it preferable over XMCD. For Pt/Fe we clearly detect an XRMR signal of some %, while for Pt/NFO we can exclude any effect within our detection limit of $< 0.05\,\%$.

[1] Y. M. Lu et al., Phys. Rev. Lett. 110, 147207 (2013)
[2] S. Geprägs et al., Appl. Phys. Lett. 101, 262407 (2012)
[3] D. Meier et al., Phys. Rev. B. 87, 054421 (2013)

MA 36.9 Thu 11:45 HSZ 04

Thermally induced spin accumulation at Al/Co_2TiSi and Al/Co_2TiGe contacts — •Voicu Popescu, Benjamin Geisler, and Peter Kratzer — Faculty of Physics, University Duisburg-Essen, Duisburg, Germany

Spin injection from a ferromagnet in a semiconductor subtrate can be accomplished either by applying an external voltage or a temperature gradient. In the latter case, one exploits the Seebeck effect, with the temperature gradient across the contact directly resulting in a difference in chemical potentials in the two spin channels due to the spin-dependence of the Seebeck coefficient.

The magnetic Heusler alloys Co_2TiSi or Co_2TiGe exhibit half-metallic ferromagnetism in their ideal $L2_1$ crystal structure, with a potentially high degree of spin polarization of the injected current. As such, they recommend themselves for integrated spin injectors in combination with the closely lattice-matched Al contact layer.

We investigate the possibility of employing Al/Co_2TiX/Al (X=Si,Ge) trilayers as thermally driven spin injectors by means of first-principles calculations of the electronic structure and of the thermoelectric transport properties. Our results show that the spin-dependent Seebeck effect is sensitive to the atomic structure of the Heusler/Al interface. In particular, for a thin Co_2TiSi or Co_2TiGe layer terminated by a TiSi or TiGe atomic plane, the thermal spin accumulation is found to be of the same order of magnitude as the conventional, effective Seebeck coefficent.

MA 36.10 Thu 12:00 HSZ 04

Influence of heat flow directions on Nernst effects in Py/Pt bilayers — •Daniel Meier[1], Daniel Reinhardt[1], Maximilian Schmid[2], Christian H. Back[2], Jan-Michael Schmalhorst[1], Timo Kuschel[1], and Günter Reiss[1] — [1]University of Bielefeld, D-33501 Germany — [2]University of Regensburg, D-93040 Germany

We investigated the voltages obtained in a thin Pt strip on a Permalloy film which was subject to in-plane temperature gradients and magnetic fields. The voltages detected by thin W-tips or bond wires showed a purely symmetric effect with respect to the external magnetic field which can be fully explained by the planar Nernst effect (PNE). To verify the influence of the contacts measurements in vacuum and atmosphere were compared and gave similar results. We explain that a slightly in-plane tilted temperature gradient only shifts the field direction dependence but does not cancel out the observed effects. Additionally, the anomalous Nernst effect (ANE) could be induced by using thick Au-tips which generated a heat current perpendicular to the sample plane. The effect can be manipulated by varying the temperature of the Au-tips. These measurements are discussed concerning their relevance in transverse spin Seebeck effect measurements.

MA 37: Spin Torque and Spin Excitations I

Time: Thursday 9:30–12:15 Location: HSZ 401

MA 37.1 Thu 9:30 HSZ 401

Goldstone modes observed in a single-k weak chiral magnet — •Max Kugler[1], Georg Brandl[1], Robert Georgii[1], Peter Böni[2], Christian Pfleiderer[2], Achim Rosch[3], Markus Garst[3], and Johannes Waizner[3] — [1]Heinz Maier-Leibnitz Zentrum (MLZ), TU München — [2]Physik Department E21, TU München — [3]Institute for Theoretical Physics, University of Cologne

The dispersion of the helimagnon modes in the weak chiral helimagnet MnSi has been measured in the momentum directions **q** parallel and perpendicular to the helix wave vector **k** using triple-axis neutron spectroscopy (TAS). In contrast to earlier measurements by Janoschek *et al.* [1], where the measurements were performed in a multi-domain state leading to the appearance of numerous modes, we applied a small magnetic field of 100 mT to enforce a single domain state thus reducing the number of modes drastically. Therefore, we succeeded to clearly identify the various magnetic modes and measure their dispersion. By inclusion of an energy gap all the data can be well reproduced by the theory on helimagnons by Belitz *et al.* [2]. However, the energy gap can neither be explained by dipolar interactions nor by the applied field because of the Goldstone theorem. For $\mathbf{q} \perp \mathbf{k}$, a multiple band structure develops in which we succeeded to resolve the first six bands. Furthermore, we investigated the renormalization of the helimagnons for both **q**-directions and achieved an excellent agreement with our magnetisation data and previous measurements in the field-induced ferromagnetic state.

[1] PRB **83**, 214436 (2010) [2] PRB **73**, 054431 (2006)

MA 37.2 Thu 9:45 HSZ 401

Tuning Spin Transfer Torques in Chiral Magnets — •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 $\sim 10^6 \mathrm{Am}^{-2}$ are exceptionally small and about 5 orders of magnitude smaller than the spin transfer torques observed in conventional systems. The low critical current density is due to a very efficient gyromagnetic coupling due to the non-trivial topology of the skyrmion lattice, as well as combination of stiffness of the skyrmion lattice and collective pinning. We report spin transfer torque experiments, based on the Hall effect in chiral magnets for various tuning parameters, where the topological Hall effect increases by up to a factor of ten suggesting a large variation of the coupling of the electric currents to the magnetic structure. The dependence of j_c on the tuning parameters will be 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 37.3 Thu 10:00 HSZ 401

Topologically Protected Magnetic Helix for All-Spin-Based Applications — •Elena Vedmedenko and David Altwein — Universität Hamburg, Deutschland

The recent years have witnessed an emergence of the field of all-spin-based devices without any flow of charge. An ultimate goal of this scientific direction is the realization of full spectrum of spin-based networks like in modern electronics. The concepts of energy storing elements, indispensable for those networks, are so far lacking. Analyzing analytically the size dependent properties of magnetic chains that are coupled via either exchange or long-range dipolar or Ruderman-Kittel-Kasuya-Yosida interactions, we discover a particularly simple law: magnetic configurations corresponding to helices with integer number of twists, that are commensurate with the chain's length, are energetically stable. With increasing number of twists the energy of the helix increases but, once achieved, remains stable at small temperatures. The higher energy levels can be reached by rotating one of the chain ends like the winding up of spring driven clocks. This finding, supported by simulations and an experimentally benchmarked model, shows that boundaries can topologically stabilize structures that are not stable otherwise. On that basis an energy storing element that uses spin at every stage of its operation is proposed [1].

[1] E. Y. Vedmedenko, D. Altwein, Phys. Rev. Lett., accepted (2013).

MA 37.4 Thu 10:15 HSZ 401

Spin dynamics and magnon lifetime close to the percolation in two dimensional diluted magnetic systems — •Akash Chakraborty[1], Paul Wenk[1], John Schliemann[1], and Georges Bouzerar[2] — [1]Institut I - Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Institut Lumiere Matiere, Universite Lyon 1-CNRS, 69622 Villeurbanne Cedex, France

Spin-wave excitations in disordered magnetic systems have been widely studied for several decades now. However, a careful search reveals a longstanding controversy on one important aspect, which is the wave-vector dependence of the spin-wave intrinsic linewidth. Different theories have predicted this dependence to be as varied as q^3 to q^7, but no general agreement has prevailed till now. We present here a detailed analysis of the low-temperature spin-wave excitations in two-dimensional diluted ferromagnetic systems and show that in the long wavelength limit the linewidth is in fact proportional to q^4. This is in good agreement with some previous theoretical studies which predicted a q^{d+2}dependence (d is the dimensionality). One of the primary difficulties in extracting the correct wave-vector dependence is the fact that this q^4 behavior holds only for very small q-values, in a restricted region of the Brillouin zone. This possibly explains the failure to observe this behavior experimentally, as it is considerably difficult to probe such small wave-vectors. In addition, we show that evaluating the linewidth from the moments associated with the spectral density leads to an incorrect linear dependence in q.

MA 37.5 Thu 10:30 HSZ 401

Self-consistent determination of the key spin transfer torque parameters from spin wave Doppler experiments — •Helmut Körner, Jean-Yves Chauleau, Hans Bauer, Johannes Stigloher, Georg Woltersdorf, and Christian Back — Department of Physics, Universität Regensburg, D-93040 Regensburg, Germany

Action of spin-polarized electric currents on magnetic textures is now well established both from experimental and theoretical viewpoints [1]. 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 [2].

In this study, we experimentally determine the key spin transfer torque parameters in a fully self-consistent approach by optically accessing current-induced spinwave dynamics in Permalloy stripes using time-resolved scanning Kerr microscopy (TRMOKE). Our technique allows precise access to spinwave characteristics and their current-induced changes, especially the change in decay length which carries the information about the non-adiabaticity.

[1] D.C. Ralph and M.D. Stiles, JMMM 321, 2508 (2009) [2] V. Vlaminck and M. Bailleul, Science 322, 410 (2008)

15 min. break

MA 37.6 Thu 11:00 HSZ 401

Influence of conduction electrons on spin dynamics — •Andreas Donges, Denise Hinzke, and Ulrich Nowak — University Konstanz, 78457 Konstanz, Germany

Current-induced domain wall (DW) motion due to the exchange interaction of s- and d-electron spins promises novel applications in data storage technologies [1]. However, when it comes to narrow DWs the spin-torque-description by Zhang and Li [2], used to describe this interaction, is not sufficient anymore and one has to take into account additional effects, such as spin-diffusion and spin-current-precession.

We numerically investigate current-driven DW motion in narrow walls using a 1-dimensional model, where localized d-electron spins are described by the Landau-Lifshitz-Gilbert-equation, whereas the equation of motion for the itinerant s-electrons has been derived from the spinor-Boltzmann-equation. Both equations are coupled via a local sd-exchange Hamiltonian and we neglect finite temperature effects. The DW velocity is studied in dependence of the wall width. We find a monotonic increase of the velocity with decreasing wall width, caused by non-equilibrium-spin-diffusion. Some systems show an additional rise in the DW velocity, when the wall width is near the spin-diffusion-length, that we link to the missing alignment of s- and d-electron-profiles.

[1] S. Parkin, et al., Science, 320, 5873 (2008)
[2] S. Zhang and Z. Li, Phys.Rev.Lett., 93, 12 (2004)

MA 37.7 Thu 11:15 HSZ 401

Spin-orbit torques in magnetic nanostructures with structural inversion asymmetry — •Roberto Lo Conte[1,3], Ales Hrabec[2], Andrei Mihai[2], Tomek Schulz[1], Thomas Moore[2], and Mathias Kläui[1,3] — [1]Institute of Physics, Johannes Gutenberg University, Staudingerweg 7, 55128 Mainz, Germany — [2]School of Physics and Astronomy, University of Leeds, LS2 9JT, U.K. — [3]Graduate School Material Science in Mainz (MAINZ), Staudingerweg 9, 55128 Mainz, Germany

Intense investigations are carried out on novel magnetic materials systems with perpendicular magnetic anisotropy (PMA) and structure inversion asymmetry (SIA). So called spin-orbit torques (SOTs) have been observed in PMA nanostructures with SIA when an electric current is injected, leading to ultra-fast current-induced domain wall motion (CIDWM) and current-induced magnetization switching [1,2]. We investigate CIDWM in PMA-nanowires made of Ta/CoFeB/MgO and Pt/CoFeB/MgO by Kerr Microscopy. By measuring the effect of an in-plane external magnetic field on the DWM, we determine the acting torques. At sufficiently large longitudinal fields we observed a strong change in the DW velocity, of different sign for the two types of DWs. This demonstrates that Néel-type DWs maximize the acting torques and that the chirality of the DWs is fixed by the Dzyaloshinskii-Moriya interaction (DMI) generated at the interfaces [3,4]. We determine the strength of the DMI-effective field and we find that in combination with the spin Hall effect in Ta and Pt, this leads to efficient wall motion in opposite directions for Ta and Pt underlayers.

MA 37.8 Thu 11:30 HSZ 401

Non-local spin transfer torque and its effect on domain wall motion — •Martin Stier and Michael Thorwart — I Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany

Current induced domain wall (DW) motion is well described by the Landau-Lifshitz-Gilbert equation which includes spin transfer torques (STT). Standard procedures lead to essentially two parts of the STT (adiabatic, non-adiabatic) which are considered to be spatially constant even in the vicinity of the DW. We present a basically exact method to solve the continuity equation which results in a non-local STT. This STT now depends sensitively on several model parameters, most prominently on the DW width, but also on the exchange coupling and the non-adiabaticity parameter. Additionally we find a quite natural reflection of the relaxation length in the STT. While for broad DWs the standard expressions of the STT are recovered, they differ completely for steep DWs. Finally, we show how the non-local STT affects the DW velocity including the impossibility to move very steep DWs.

MA 37.9 Thu 11:45 HSZ 401

Micromagnetic simulation of a spin-torque oscillator driven by pure spin currents — •Henning Ulrichs, Vladislav E. Demidov, and Sergej O. Demokritov — Institut für angewandte Physik, WWU Münster, Corrensstraße 2-4, 48149 Münster

In this talk a micromagnetic simulation of a novel kind of spin torque nano-oscillator compromising a patterned Pt / NiFe double layer is presented. The operational principle of this oscillator relies on the spin-Hall effect in the Pt. In contrast to conventional spin-torque oscillators, the spin-torque is conveyed by pure spin currents, flowing from the Pt into the NiFe. The numerical results support the experimental claim that the dominant auto-oscillation mode is the spin-wave bullet mode. Moreover, a recently experimentally observed secondary mode is also found in the simulation. Spatial features of the bullet mode, which are in experiments obscured due to optical limitations, are investigated. It is shown that the diameter of the spin-wave bullet is about 80 nm. The physical nature of the secondary mode is elucidated.

MA 37.10 Thu 12:00 HSZ 401

Spin torque switching of an in-plane magnetized system in a thermally activated region — Tomohiro Taniguchi[1], Yasuhiro Utsumi[2], •Michael Marthaler[3], Dmitri Golubev[3], and Hiroshi Imamura[1] — [1]Spintronics Research Center, AIST, Tsukuba — [2]Faculty of Engineering, Mie University, Tsu — [3]Institut für Theoretische Festkörperphysik, KIT, Karlsruhe

The current dependence of the exponent of the spin torque switching rate of an in-plane magnetized system was investigated by solving the Fokker-Planck equation with low temperature and small damping and current approximations. We derived the analytical expressions of the critical currents, I_c and I_c^*. At I_c, the initial state parallel to the easy axis becomes unstable, while at I_c^* ($\simeq 1.27 I_c$) the switching occurs without the thermal fluctuation. The current dependence of the exponent of the switching rate is well described by $(1 - I/I_c^*)^b$, where the value of the exponent b is approximately unity for $I < I_c$, while b rapidly increases up to 2.2 with increasing current for $I_c < I < I_c^*$. The linear dependence for $I < I_c$ agrees with the other works, while the nonlinear dependence for $I_c < I < I_c^*$ was newly found by the present work. The nonlinear dependence is important for analysis of the experimental results, because most experiments are performed in the current region of $I_c < I < I_c^*$.

MA 38: Magnetic Materials II

Time: Thursday 9:30–12:15 Location: HSZ 403

MA 38.1 Thu 9:30 HSZ 403

Synthesis and properties of ultrathin B2 ordered FeRh films — •Ralf Witte, Richard Brand, Robert Kruk, and Horst Hahn — Karlsruhe Institute of Technology KIT, Institute for Nanotechnology, 76344 Eggenstein, Germany

The B2 ordered phase (CsCl structure) of the Fe50Rh50 alloys possess interesting magnetic properties. They are antiferromagnetically (AFM) coupled at room temperature and show a transition to a ferromagnetic phase (FM) at about 400K. This behavior has been shown 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 9 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. So far there has been no clear experimental confirmation of the theoretical results, mainly because of the difficulties in growing B2-ordered FeRh alloys in the form of an epitaxial, ultra-thin film. We present research on the synthesis and properties of FeRh thin films on different single crystalline 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 57Fe Mössbauer spectroscopy.

[1] S. Lounis, Phys. Rev. B 67, 094432 (2003)

MA 38.2 Thu 9:45 HSZ 403

Ferromagnetic resonance in FeRh thin films through the magnetic phase transition — •Alireza Heidarian[1,2], Jürgen Lindner[1], Rantej Bali[1], and Kay Potzger[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

The temperature-induced antiferromagnetic (AF) to ferromagnetic (FM) phase transition of epitaxial FeRh/MgO (001) thin films is studies by means of ferromagnetic resonance (FMR). The FM as well as the AFM phase can be separated via temperature- and field dependent FMR. Our measurements show that temperature dependent FMR can be used to determine the relative volumes of AFM and FM regions across phase transition. Moreover, the temperature dependent magnetic coupling strength could be investigated. While decreasing the film thickness, the phase transition temperature shifts towards lower temperatures, which could result from the strain between substrate and the thin film.

MA 38.3 Thu 10:00 HSZ 403

Atomic Structure, Magnetic Anisotropy and Magnetization Reversal in Fe films on Pt(997) — Rafael Fradczyk, Hauke Bardenhagen, Kim-Mario Wolf, Stephan Rutsch, Matthias Nuss, and •Kai Fauth — Physikalisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg

Vicinal surfaces may serve as templates for the growth of films with nanoscale structural and strain modulation. In magnetic materials this gives rise to various contributions to the magnetic anisotropy energy density.

In the present contribution we revisit [1] the growth of Fe on Pt(997) and the resulting magnetic properties. Under optimized growth conditions, we observe notable structural differences to previous reports from electron diffraction (LEED, LEED-IV). The magnetic easy axis, while still in the surface plane, appears rotated by 90° as a result. Our results suggest that the atomic structure established at the step edges provides the dominant contribution to the magnetocrystalline anisotropy energy density, even above the spin reorientation thickness.

We present and analyze in detail ambient and low temperature saturation magnetization, anisotropy field(s) and magnetization reversal at a Fe film thickness of five atomic layers.

[1] D. Repetto et al., *Phys. Rev. B* **74**, 054408 (2006)

MA 38.4 Thu 10:15 HSZ 403

Perpendicular magnetic anisotropy in epitaxial $DyCo_5$ thin films — •Benjamin Schleicher[1,2], Marietta Seifert[1], Ludwig Schultz[1,2], and Volker Neu[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, 01171 Dresden — [2]Technische Universität Dresden, Institute for Solid State Physics, 01062 Dresden

The ferrimagnetic $DyCo_5$ phase was prepared as epitaxial thin films with a thickness of 50 nm by pulsed laser deposition from elementary targets in an UHV environment. The use of Cr-buffered MgO(110) substrates results in an in-plane growth of the unit cells' crystallographic *c*-axis. 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. The remanent magnetization has been measured in a temperature range from 20 K to 400 K along distinct crystallographic directions as well as hysteresis loops at discrete temperatures to probe the anisotropic behavior of the samples. Furthermore, MFM measurements were carried out in a temperature range from 300 K to 400 K. The ferrimagnetic coupling between the heavy rare earth Dy and the transition metal Co was confirmed by identifying a minimum of the magnetization of the sample at the so called spin compensation temperature. The value of roughly 110 K is in qualitative agreement with literature data of single crystals and varies with the amount of Dy in the film. A spin reorientation transition from easy *c*-axis via easy cone to easy plane was observed between 400 K and 325 K, and leads to a perpendicular anisotropy of the film below 325 K with an out-of-plane easy axis.

15 min. break

MA 38.5 Thu 10:45 HSZ 403

Epitaxial Ni-Mn-Ga-Co films for magnetocaloric application — •Anett Diestel[1,2], Robert Niemann[1], Sebastian Fähler[1,3], and Ludwig Schultz[1,2] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, 01171 Dresden, Germany — [2]Technische Universität Dresden, Institute of Materials Science, 01062 Dresden, Germany — [3]Technische Universität Chemnitz, Institute of Physics, 09126 Chemnitz, Germany

The Heusler alloys Ni-Mn-X-Co (X = Ga, In, Sn, Sb) exhibit an inverse magnetocaloric effect (MCE) due to a field-induced martensitic transformation between austenite and modulated martensite which is accompanied by a large change of magnetization. The transformation temperatures sensitively depend on composition and chemical order so room temperature solid state refrigeration becomes feasible. For Ni-Mn-Ga-Co bulk an inverse MCE is known in comparison to the direct MCE of Ni-Mn-Ga. We prepared epitaxial Ni-Mn-Ga-Co films by magnetron sputter deposition on single crystalline MgO(100) substrates. Due to the high surface-to-volume fraction of thin films a fast heat exchange is possible and a higher cooling power can be achieved using less material. We proved epitaxial growth and the reversible field induced transformation from austenite to modulated martensite with a high change of magnetization. We also show the strong influence of deposition parameter and chemical composition on film growth, transformation temperatures and chemical order which influence the shape of magnetic hysteresis. This work is supported by DFG through SPP 1599 www.FerroicCooling.de.

MA 38.6 Thu 11:00 HSZ 403

Martensitic Transformation in Freestanding Magnetocaloric Thin Films — •Lars Helmich[1], Niclas Teichert[1], Walid Hetaba[2], Anna Behler[3], Anja Waske[3], and Andreas Hütten[1] — [1]Bielefeld University, Department of Physics, Thin Films and Physics of Nanostructures, 33615 Bielefeld, Germany — [2]Vienna University of Technology, USTEM, A-1040 Vienna, Austria — [3]TU Dresden, Institut für Festkörperphysik, 01062 Dresden, Germany

Ni-Mn-Sn is a well-known ferromagnetic shape memory alloy that shows both a martensitic transformation and the magnetocaloric effect for a suitable choice of stoichiometry. However a direct observation of the temperature change due to the magnetocaloric effect is a challenging task for thin films since the substrate provides a large heat sink.

We prepared Ni-Mn-Sn films on heated MgO(001) substrates with a sacrificial layer in between by magnetron sputtering. In a subsequent preparation step the substrate was removed by wet-chemical treatment. Thus we prepared freestanding films with a thickness in the range of 100 nm and therefore we got rid of the heat sink. This offers the possibility for direct ΔT-measurements.

Moreover the removal of the substrate leads to a reduction of strain effects in the film. We showed that this again results in a lowering of the martensite transition temperature. Furthermore changes in electronic and magnetic properties were analysed.

MA 38.7 Thu 11:15 HSZ 403

Influence of the film thickness on the martensitic transition in free-standing Ni-Mn-Sn thin films — •Svetlana Klimova[1,2], Niclas Teichert[2], Lars Helmich[2], Andreas Hütten[2], Anna Behler[3], Anja Waske[3,4], and Walid Hetaba[2,5] — [1]Saratov State University, Department of Nano- and biomedical Technology, 410012 Saratov, Russia — [2]Bielefeld University, Department of Physics, Thin Films and Physics of Nanostructures, 33615 Bielefeld, Germany — [3]IFW Dresden, Institute for Complex Materials, 01069 Dresden, Germany — [4]TU Dresden, Institut für Festkörperphysik, 01062 Dresden, Germany — [5]TU Wien, Universitäre Service-Einrichtung für Transmissionselektronenmikroskopie (USTEM), 1040 Wien, Austria

Magnetic materials based on Ni-Mn-Sn are Heusler alloys, in which a structural transition carries out from the low temperature martensitic to the high temperature austenitic phase. In this study we have synthesized the free-standing Ni-Mn-Sn thin films between 20 nm and 200 nm and transferred onto different substrates (Si or GaAs wafers, cupper grids or glass) to investigate the influence of the film thickness on the martensitic transition. The films were epitaxially grown on MgO (001) substrates with a sacrificial V layer by DC magnetron co-sputtering at a substrate temperature of 500°C. This allows to study the substrate influence on the martensitic transition. The applied methods to study the martensitic transition include temperature dependent resistivity and magnetization measurements, X-Ray Diffraction, and Transmission Electron Microscopy.

MA 38.8 Thu 11:30 HSZ 403

Magnetocaloric and hysteretic properties of Ni-Mn based Heusler alloys — •Tino Gottschall, Konstantin Skokov, Bianca Frincu, and Oliver Gutfleisch — TU Darmstadt, Germany

The origin for the inverse magnetocaloric effect in Ni-Mn based Heusler alloys is a first-order magnetostructural transition between a low temperature paramagnetic/antiferromagnetic martensite and a high temperature ferromagnetic austenite phase. Performing direct measurements, we report a large adiabatic temperature change ΔTad exceeding -8 K at a field change of 2 T in the Ni-Mn-In-(Co) Heusler system. The thermal hysteresis of more than 8 K reduces the magnetocaloric effect drastically when the magnetic field is applied a second time. Nevertheless, we observe a cyclic adiabatic temperature change in the same field change of -3 K when moving in minor loops of magnetization, where only a certain part of the material transforms. The hysteretic behavior of the transition was in situ studied by optical microscopy.

MA 38.9 Thu 11:45 HSZ 403

Low temperature scanning tunneling microscopy of the $Ni_2MnGa(001)$ surface. — •Niklaus Blenk[1], Aleksej Laptev[1], Mikhail Fonin[1], S. W. D'Souza[2], and Sudipta Roy Barman[2] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz — [2]UGC-DAE Consortium for Scientific Research, 452001 Indore, India

Due to their possible applications as actuators and sensors ferromagnetic shape memory alloys (FSMA) have attracted strong scientific interest. Ni-Mn-Ga is the most prominent and the most studied FMSA due to demonstrated magnetic field induced strains of up to 12% [1].

Here we report on low temperature STM-measurements on the $Ni_2MnGa(001)$ surface performed at 10 K. At this temperature the Ni_2MnGa single crystal is in the ferromagnetic state and shows a 5M modulated martensitic structure. We observe charge-density modulations with a wavelength of 1.4 nm and wavefronts aligned along the [010] direction associated with a bulk charge-density wave (CDW). The modulation period is shown to be independent on the tunneling voltage U_T. On the other hand the resulting corrugation amplitude depends on U_T. A phase shift in the modulation appears at around 100 mV.

The observed co-existence of ferromagnetism and a CDW in Ni_2MnGa is in agreement with the observation of a pseudogap, which hallmarks the CDW, by photoemission techniques [2,3].

[1] A. Sozinov et al., Appl. Phys. Lett. 102, 021902 (2013).
[2] D'Souza et al., Phy. Rev. B 85, 085123 (2012).
[3] C. P. Opeil et al., Phys. Rev. Lett. 100, 165703 (2008).

MA 38.10 Thu 12:00 HSZ 403

Unraveling nanotwinned martensites in Ni_2MnGa from first-principles — •Markus Ernst Gruner[1,2], Ulrich K. Rössler[1], and Sebastian Fähler[1,3] — [1]IFW Dresden — [2]Universität Duisburg-Essen — [3]TU Chemnitz

The unique magnetic shape memory properties of the Heusler compound Ni_2MnGa are intimately connected with the presence of modulated structures. These were recently interpreted in terms of an adaptive arrangement of [110] aligned nanotwins consisting of non-modulated tetragonal $L1_0$ building blocks, which is considered as the ground state of this compound. This implies, that the energy of the nanotwinned microstructure can be decomposed into the contribution from the $L1_0$ volume fraction, the twin interface energy and the interaction between two neighboring interfaces at a given separation. Based on comprehensive total energy calculations in the framework of density functional theory calculations we verify this building principle through a systematic evaluation of twinned microstructures constructed from strained $L1_0$ martensite with different c/a. For the equilibrium distortion of martensite, $c/a = 1.26$, we observe indeed nearly perfect additivity of the corresponding contributions. Furthermore, we find that for intermediate distortions specific nanotwinned configurations can be significantly lower in energy than the respective nonmodulated building blocks. In particular, the so-called 4O orthorhombic structure consisting of two double-layer twins becomes energetically comparable to the nonmodulated $L1_0$ ground state martensite.

MA 39: Focus Session: Unconventional Spin Structures (jointly with DS)

Organizer: J. Fassbender (HZDR)

Time: Thursday 9:30–12:45 Location: BEY 118

Topical Talk MA 39.1 Thu 9:30 BEY 118

Topological Effects in Nanomagnetism - From Perpendicular Recording to Monopoles — •Hans-Benjamin Braun — University College Dublin

Similar to knots in a rope, the magnetization in a material can form particularly robust configurations. Such topologically stable structures include domain walls, vortices and skyrmions which are not just attractive candidates for future data storage applications but are also of fundamental importance to current memory technology. For example, the creation of soliton pairs of opposite chirality delimits the thermal stability of bits in current high anisotropy perpendicular recording media. After an introduction into various types of topological defects and their implications for current data storage it will be discussed how vortices can be robustly implemented in a system of nanoislands, a system that is in principle scaleable to the smallest length scales. It will then be shown how magnetic monopoles emerge as topological defects in densely packed arrays of nanoislands, a system also known as artificial spin ice. In contrast to conventional thin films, where magnetization reversal occurs via nucleation and extensive domain growth, magnetization reversal in 2D artificial spin ice is restricted to an avalanche-type formation of 1D strings. These objects can be viewed as classical versions of Dirac strings that feed magnetic flux into the emergent magnetic monopoles. It is demonstrated how the motion of these magnetic charges can be individually controlled experimentally and used to perform simple logic operations.

Topical Talk MA 39.2 Thu 10:00 BEY 118

Topology and Origin of Effective Spin Meron Pairs in Ferromagnetic Multilayer Elements — •Sebastian Wintz — Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Topological spin textures, such as vortices or skyrmions, are attracting significant attention because of their intriguing fundamental properties as well as their promising applicability in memory devices or spin torque oscillators. A particular topological texture that was theoretically predicted is the two-dimensional hedgehog state, also known as a 'Spin Meron'. It had been unclear, however, whether this kind of highly divergent magnetization structure can exist in real continuum systems. Only recently, evidence for the occurrence of meron-like states was reported for trilayer elements consisting of two ferromagnetic layers and a non-ferromagnetic interlayer [1]. On this background we now present a direct proof for the existence of meron-like states in trilayer elements via direct magnetic imaging. We also show that in the presence of biquadratic interlayer exchange coupling, such meron-like pair states may even represent the magnetic ground state of the system. Interestingly, the highly divergent magnetization distribution induces an additional, three-dimensional torus vortex that in-turn causes a symmetry break for the allowed topological pair configurations. [1] C. Phatak et al., Phys. Rev. Lett. 108, 067205 (2012). [2] S. Wintz et al., Phys. Rev. Lett. 110, 177201 (2013).

Topical Talk MA 39.3 Thu 10:30 BEY 118

Symmetry breaking in the formation of magnetic vortex states in a permalloy nanodisk — •Peter Fischer[1], Mi-Young Im[1], Keisuke Yamada[2], Tomonori Sato[3], Shinya Kasai[4], Yoshinobu Nakatani[3], and Teruo Ono[2] — [1]CXRO, LBNL, Berkeley CA USA — [2]Inst. f.Chem. Res., Kyoto University Japan — [3]U of Electro-Comm., Chofu, Japan — [4]Spintronics Group, Magn. Mat Center, NIMS, Tsukuba, Japan

Mesoscale phenomena will transform nanomagnetism research to the next level [1], as they add complexity and functionality, which are essential to meet future challenges of spin driven devices.

A priori, one would assume that the formation of magnetic vortex states should exhibit a perfect symmetry, because the magnetic vortex has four degenerate states. We report on the direct observation of an asymmetric phenomenon in the formation process of vortex states in a permalloy nanodisk by magnetic full field transmission soft x-ray microscopy [2]. Micromagnetic simulations confirm that an intrinsic Dzyaloshinskii*Moriya interaction is decisive for the asymmetric formation of vortex states.

Supported by the U.S. Department of Energy (# DE-AC02-05-CH11231) and by the Leading Foreign Research Institute Recruitment Program (# 2012K1A4A3053565) through the NRF of Korea funded by the Ministry of Education, Science and Technology.

[1] R. Service, Science 335 1167 (2012) [2] M.-Y. Im, P. Fischer, Y. Keisuke, T. Sato, S. Kasai, Y. Nakatani, T. Ono, Nature Communications 3 983 (2012)

15 min. break

Topical Talk MA 39.4 Thu 11:15 BEY 118

Commensurability and chaos in magnetic vortex oscillations — •Joo-Von Kim[1], Sébastien Petit-Watelot[1], Antonio Ruotolo[2,3], Rubén Otxoa[1], Karim Bouzehouane[2], Julie

Grollier[2], Arne Vansteenkiste[4], Ben Van de Wiele[5], Vincent Cros[2], and Thibaut Devolder[1] — [1]Institut d'Electronique Fondamentale, UMR CNRS 8622, Univ. Paris-Sud, 91405 Orsay, France — [2]Unité Mixte de Physique CNRS/Thales and Univ. Paris-Sud, 1 av. A. Fresnel, 91767 Palaiseau, France — [3]Department of Physics and Materials Science, City University of Hong Kong, Kowloon, Hong Kong — [4]Department of Solid State Sciences, Ghent University, Krijgslaan 281-S1, B-9000 Ghent, Belgium — [5]Department of Electrical Energy, Systems and Automation, Ghent University, Sint-Pietersnieuwstraat 41, B-9000 Ghent, Belgium

In spin-torque driven vortex oscillations in small nanocontacts, periodic reversal of the vortex core appear above a critical current and results in a self-modulation phenomenon involving gyration and relaxation oscillations. By tuning the ratio between the gyration frequency and the rate of core reversal, we show that commensurate phase-locked and incommensurate chaotic states are possible, resulting in Devil's staircases with driving currents. This represents a novel dynamical regime for vortex dynamics in which the gyrotropic dynamics is self-modulated by the periodic core reversal.

Topical Talk MA 39.5 Thu 11:45 BEY 118

Dynamic ordering of vortex cores in interacting mesomagnets — •Valentyn Novosad — Materials Science Division, Argonne National Laboratory, Argonne, IL 60439, USA

Manipulation of the magnetization is a key problem in applied magnetism. In this talk a novel method of controlling the ground state using two interacting vortices as a model system will be presented. A spin vortex consists of an in-plane and out-of-plane (core) regions of magnetization. Control of an in-plane magnetization has been demonstrated previously, whereas manipulation of the vortex cores remain challenging. In our work this is achieved by driving the system from the linear regime of constant vortex gyrations to the non-linear regime of vortex-core reversals at a fixed excitation frequency of one of the coupled modes. Subsequently reducing the excitation field to the linear regime, stabilizes the system to a polarity combination whose resonant frequency is decoupled from the initialization frequency [2]. The transition of the state from one polarity combination to the other is clearly evident from the contrast in the microwave absorption amplitude obtained by gradually increasing the rf-field to higher magnitudes at the resonant frequency of one of the modes and subsequently decreasing it. The results of this work may benefit future advancement of dynamically controlled spintronic devices, such as magnonic crystals, spin-torque oscillators, and magnetic memories.

[1] S. Jain, et al., Applied Physics Letters, 102, 052401 (2013).
[2] S. Jain et al., Nature Comm., DOI: 10.1038/ncomms2331 (2012).

Topical Talk MA 39.6 Thu 12:15 BEY 118

Magnetic Vortex Core Reversal by Excitation of Spin Waves — •Hermann Stoll[1], Matthias Kammerer[1], Matthias Noske[1], Markus Sproll[1], Georg Dieterle[1], Ajay Gangwar[1,2], Markus Weigand[1], Manfred Fähnle[1], Georg Woltersdorf[2], Christian H. Back[2], and Gisela Schütz[1] — [1]MPI for Intelligent Systems, Stuttgart, Germany — [2]University of Regensburg, Germany

Essential progress in the understanding of nonlinear magnetic vortex dynamics was achieved when low-field vortex core reversal by (sub-GHz) excitation of the vortex gyromode was observed using time-resolved scanning transmission X-ray microscopy [1]. This switching scheme, based on the creation and subsequent annihilation of a vortex-antivortex pair [1,2], has been proved to be universal and independent of the type of excitation, e.g., pulsed magnetic fields or spin transfer torque (STT).

Magnetic vortex structures possess azimuthal spin wave modes showing eigenfrequencies in the multi-GHz range. We could demonstrate [3-5] by experiments and micromagnetic simulations that even much faster unidirectional vortex core reversal can be achieved by exciting these spin wave modes with (multi-GHz) rotating magnetic fields. In that way we have been able to switch vortex cores selectively within less than 100 ps.

[1] B. Van Waeyenberge et al., Nature 444, 462 (2006) [2] A. Vansteenkiste et al., Nature Physics 5, 332 (2009) [3] M. Kammerer et al., Nature Communications 2, 279 (2011) [4] M. Kammerer et al., PRB 86, 134426 (2012) [5] M. Kammerer et al., APL 102, 012404 (2013)

MA 40: Graphene-like materials: Silicene, MoS_2 and relatives (with DY/DS/HL/O/TT)

Time: Thursday 10:00–12:30 Location: POT 081

MA 40.1 Thu 10:00 POT 081

Many-body effects in 2D hexagonal semimetals and semiconductors — •Tineke Stroucken, Johanna Grönqvist, and Stephan W. Koch — Department of Physics and Material Sciences Center, Philipps University Marburg, Renthof 5, D-35032 Marburg, Germany

Recently, a variety of graphene-analogues materials like h-BN, silicene or transition-metal dichalcogenides have been fabricated. Similar to graphene, these novel material systems display exciting new physical properties, distinct from their bulk counterparts.

Owing to the symmetry of the hexagonal lattice, band edge carriers are described by massive Dirac Fermions. Typically, the Fermi-velocity is in the range of $c/300$ or below. This yields effective fine structure constants $\alpha = e^2/\epsilon\hbar v_F \gtrsim 2/\epsilon$, implying prominent Coulomb interaction and relativistic effects. Particularly, $\alpha \gtrsim 1$ indicates an excitonic instability of the noninteracting ground state.

In this presentation, we discuss conditions for strong Coulomb coupling in 2D hexagonal crystals and identify experimentally observable signatures signaling an excitonic ground state. To this end, the gap equations are solved self consistently with the polarization function, which depends on the interacting band structure.

[1] T. Stroucken *et al.*, Phys. Rev. B 84, 205445 (2011)
[2] J. H. Grönqvist *et al.*, EPJ B 85, 12 (2012)
[3] T. Stroucken *et al.*, Phys. Rev. B. 87, 245428(2013)
[4] T. Stroucken *et al.*, Appl. Phys. Lett. 103, 163103 (2013)

MA 40.2 Thu 10:15 POT 081

Single and Multi-Layer Silicene: Growth, Properties and Perspectives — •Patrick Vogt[1], Thomas Bruhn[1], Andrea Resta[2], Paola De Padova[3], and Guy Le Lay[2] — [1]Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Aix-Marseille University, CNRS- PIIM UMR 7345, F-13397 Marseille Cedex 20, France — [3]Instituto di Struttura della Materia, Consiglio Nazionale delle Ricerche -ISM, via Fosso del Cavaliere, 00133 Roma, Italy

Silicene, a new silicon allotrope with a graphene-like honeycomb structure, has recently attracted considerable interest, because its topology confers to it the same remarkable electronic properties as those of graphene, with the potential advantage of being easily integrated in current Si-based nano/micro-electronics offering novel technological applications.

We will discuss the epitaxial formation of single layer silicene on Ag substrates and its structural and electronic properties [1-2]. Based on these results we will look at the growth of silicene multi-layers which can be explained by stacking of single silicene sheets [3-4]. Different experimental techniques are used to investigate atomic structure and electronic properties of this layered system and to discuss its similarities to graphite.

1) Vogt, P. et al., Phys. Rev. Lett. 108, 155501 (2012).
2) Avila, J. et al., J. Phys.: Condens. Matter 25, 262001 (2013).
3) De Padova, P.; Vogt, et al. Appl. Phys. Lett. 102, 163106 (2013).
4) Resta, A. et al., Sci. Rep. 3, 2399 (2013).

MA 40.3 Thu 10:30 POT 081

Optical and vibrational properties of MoS2 — •Ludger Wirtz[1], Alejandro Molina-Sanchez[1], and Kerstin Hummer[2] — [1]Physics and Materials Science Research Unit, University of Luxembourg — [2]Faculty of Physics, University of Vienna, Austria

Monolayer MoS2 is currently receiving a lot of attention as a potential alternative to graphene. Its band gap of about 2eV (depending on the dielectric environment) makes it a suitable candidate for thin-film electronics. The optical and vibrational properties of mono-layer, few-layer, and bulk are seemingly straightforward to calculate. Nevertheless some surprises occur: the phonon dispersion displays an anomalous Davydov splitting and the optical absorption spectra display a rich structure of excitonic peaks in the band-gap and in the continuum of interband transitions. We give a short review of the state-of-the art and discuss recent advances in the understanding of the influence of the substrate on the vibrations and electronic excitations.

MA 40.4 Thu 10:45 POT 081

Carrier- and valley dynamics of singlelayer MoS_2 — •Gerd Plechinger[1], John Mann[2], Christian Schüller[1], Ludwig Bartels[2], and Tobias Korn[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Chemistry, Physics, and Materials Science and Engineering, University of California, CA 92521 Riverside, USA

Consisting of an only 0.7 nm thin S-Mo-S sheet and offering a direct bandgap at the K-points in the Brillouin zone, singlelayer MoS_2 represents a promising semiconductor material for flexible and transparent optoelectronic applications. By means of chemical vapor deposition (CVD), large-area films (several mm^2) of singlelayer MoS_2 can be produced. These were characterised by photoluminescence and Raman spectroscopy. In order to investigate the carrier dynamics, we performed pump-probe measurements in the spectral range of the optical transitions in singlelayer MoS_2. Helicity-resolved PL measurements have demonstrated an efficient valley polarisation of the K^+ or K^- valley at near-resonant excitation. We probe these valley dynamics with Kerr spectroscopy and find a biexponential decay of the valley polarisation with decay times of a few tens of ps and a few hundreds of ps at low temperatures.

Coffee break (15 min.)

MA 40.5 Thu 11:15 POT 081

Photocurrent studies on semiconducting MoS2 — Marina Hoheneder, •Eric Parzinger, Alexander Holleitner, and Ursula Wurstbauer — Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4a, 85748 Garching

The current interest in transition metal dichalcogenides is stimulated by their peculiar electrical and optoelectrical properties and their potential for novel device applications. We investigate the semiconductor MoS2, which shows a crossover from an indirect to a direct bandgap semiconductor by thinning it down to a monolayer. We prepare MoS2 samples through micromechanical exfoliation and characterize the thin flakes with Raman spectroscopy. We further study photocurrent generation of single and few layer MoS2 in dependence of wavelength and power of the exciting light. We gratefully acknowledge financial support by BaCaTec.

MA 40.6 Thu 11:30 POT 081

Resonant Inelastic Light Scattering on MoS_2 — •Bastian Miller, Eric Parzinger, Alexander Holleitner, and Ursula Wurstbauer — Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4a, 85748 Garching (Germany)

Two-dimensional layered 'van-der Waals' materials are of increasing interest for fundamental research due to their peculiar band-structure.

We utilize inelastic light scattering - a contactless and extremely versatile tool - to study phonon excitation spectra of mono- and fewlayer MoS_2. The phonon modes are unique fingerprints of the material properties and are sensitive to defects, strain, doping and the number of MoS_2 -layers.

We observe signatures of multistep scattering processes involving phonon-phonon, electron-phonon as well as electronic excitations under resonant conditions, where the incoming or outgoing light meets the energy of a fundamental optical transition of the system.

MA 40.7 Thu 11:45 POT 081

The effect of substrate and environment on the elementary excitations of MoS_2 — •Eric Parzinger[1], Marina Hoheneder[1], Bastian Miller[1], Anna Cattani-Scholz[1], Alexander Holleitner[1], Joel W. Ager[2], and Ursula Wurstbauer[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4a, 85748 Garching (Germany) — [2]Joint Center for Artificial Photosynthesis, Lawrence Berkeley National Laboratory, One Cyclotron Road, Berkeley, California 94702 (United States)

The novel two-dimensional layered 'van-der Waals' material Molybdenum disulfide (MoS_2) is investigated using inelastic and resonant light scattering - a contactless and extremely versatile tool - to study phonon and electronic excitations. In particular, we focus on the influence of different supporting materials (SiO_2, sapphire and SAMs of organic molecules) as well as various environmental conditions (ambient, vacuum and water) on the low energy excitations of MoS_2. We find that both, different substrate and environment give rise to a significant modification of the most prominent Raman modes, whereas a monolayer is most effected by the environmental conditions. We gratefully acknowledge financial support by BaCaTec.

MA 40.8 Thu 12:00 POT 081

Spin-orbit coupling, quantum dots, and qubits in transition metal dichalcogenides — •Andor Kormanyos[1], Viktor Zolyomi[2], Neil Drummond[2], and Guido Burkard[1] — [1]Universität Konstanz — [2]Lancaster University

We derive an effective Hamiltonian describing the dynamics of electrons in the conduction band of transition metal dichalcogenides (TMDC) in the presence of perpendicular electric and magnetic fields. We discuss both the intrinsic and Bychkov-Rashba spin-orbit coupling (SOC) induced by an external electric field. We identify a new term in the Hamiltonian of the Bychkov-Rashba SOC which does not exist in III-V semiconductors. We point out important differences in the spin-split conduction band between different TMDC compounds. A significant consequence of the strong intrinsic SOC is an effective out-of-plane g-factor for the electrons which differs from the free-electron g-factor $g \simeq 2$. Using first-principles calculations, we give estimates of the various parameters appearing in the theory. Finally, we consider quantum dots (QDs) formed in TMDC materials and derive an effective Hamiltonian allowing us to calculate the magnetic field dependence of the bound states in the QDs. We find that all states are both valley and spin split, which suggests that these QDs could be used as valley-spin filters. We explore the possibility of using spin and valley states in TMDCs as quantum bits, and conclude that, due to the relatively strong intrinsic SOC in the conduction band, the most realistic option appears to be a combined spin-valley (Kramers) qubit at low B fields.

MA 40.9 Thu 12:15 POT 081

Analytical approach to excitonic properties of MoS2 — •Gunnar Berghäuser and Ermin Malic — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We present an analytical investigation of the optical absorption spectrum of monolayer molybdenum disulfide (MoS2). Based on the density matrix formalism [1], our approach gives insights into the microscopic origin of excitonic transitions, their relative oscillator strength, and binding energy [2]. We show analytical expressions for the carrier-light coupling element, which contains the optical selection rules and well describes the valley- selective polarization in MoS2 . In agreement with experimental results, we find the formation of strongly bound electron-hole pairs due to the efficient Coulomb interaction. The absorption spectrum of MoS2 on a silicon substrate features two pronounced peaks at 1.91 eV and 2.05 eV corresponding to the A and B exciton, which are characterized by binding energies of 420 meV and 440 meV, respectively. Our calculations reveal their relative oscillator strength and predict the appearance of further low-intensity excitonic transitions at higher energies. The presented approach is applicable to other transition metal dichalcogenides and can be extended to investigations of trion and biexcitonic effects.

[1] E. Malic and A. Knorr, Graphene and Carbon Nanotubes: Ultrafast Optics and Relaxation Dynamics, 1st ed. (Wiley-VCH, Berlin, 2013).

[2] Gunnar Berghäuser and Ermin Malic, arXiv:1311.1045 (2013)

MA 41: Spintronics 2 (with HL/TT)

Time: Thursday 10:00–12:15 Location: POT 151

MA 41.1 Thu 10:00 POT 151

Magnetotransport in nanostructured InAs-based Heterostructures — •Olivio Chiatti[1], Sven S. Buchholz[1], Wolfgang Hansen[2], Mehdi Pakmehr[3], Bruce D. McCombe[3], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, D-10099 Berlin — [2]FG Wachstum, Institut für Angewandte Physik, Universität Hamburg, D-20148 Hamburg — [3]Dept. of Physics, University at Buffalo, the State University of New York, Buffalo, NY 14260-1500 USA

The control of spin-polarized currents entirely by electrical fields is of great interest in the field of spintronics. The spin-orbit coupling in narrow-gap semiconductors has been identified as a possible tool to this end, because it couples the momentum of an electron to its spin. Nanostructures can be used to filter specific momentum modes and offer the possibility to create and detect spin-polarized currents. [1] Quantum point contacts (QPCs) in nominally symmetric InAs quantum well structures have been reported to generate spin-polarized currents, when asymmetric gate voltages are applied. [2]

We have fabricated Hall-bars and QPCs with in-plane gates in InAs quantum well structures, and performed transport measurements at low temperatures and in high magnetic fields. We investigate the effects of symmetric and asymmetric gate voltages. Here, we present the results of our measurements and discuss their implications for investigations of the spin-orbit coupling in InAs.

[1] Silsbee, *J. Phys.: Condens. Matter* **16**, R179 (2004)
[2] Debray *et al.*, *Nature Nanotech.* **4**, 759 (2009)

MA 41.2 Thu 10:15 POT 151

Acoustic charge and spin transport in GaAs (111)B quantum wells — •Alberto Hernández-Mínguez, Klaus Biermann, and Paulo Santos — Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany

The special properties of electron spin dynamics in GaAs (111) quantum wells (QWs) have been subject of study during the last years. Recently, it has been experimentally shown that, to first order in the electron wavevector, the in-plane component of the spin-orbit interaction can be suppressed simultaneously for all electrons in the QW just by applying an electric field of a certain amplitude perpendicularly to the QW plane. As a consequence, by tuning the amplitude of the electric field, the spin polarization lifetime of an electron ensemble is varied from a few hundred picoseconds to tens of nanoseconds.

In addition, surface acoustic waves (SAWs) have proved to be an useful tool for the controlled transport and manipulation of electron spins in GaAs QWs: the piezoelectric field accompanying the SAW allows the spatial confinement of electrons and their transport, with the well defined SAW velocity, over distances of several tens of micrometers. In this contribution, we explore the generation of SAWs in GaAs (111) QWs, as well as their combination with vertical electric fields for the acoustic transport of long living electron spins. In this way, we observe acoustic charge transport along 40μm distance, and spin transport around 15 μm.

MA 41.3 Thu 10:30 POT 151

Indirect Excitons Spin manipulation in GaAs/Al$_x$Ga$_{1-x}$As double quantum wells — •Adriano Violante[1], Snežana Lazić[2], Klaus Biermann[1], Rudolph Hey[1], Paulo Santos[1], Kobi Kohen[3], and Ronen Rapaport[3] — [1]Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany — [2]Departamento de Física de Materiales, Universidad Autónoma de Madrid, Madrid, Spain — [3]Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem, Israel

A spatially indirect exciton (IX) is a bound state of an electron and a hole localized in different quantum wells (QWs) of a double quantum well structure (DQW). In an IX, the spatial separation of electrons and holes reduces the exchange interaction, thus significantly enhancing the spin lifetime with respect to the direct QW excitons. [1] In this contribution, we show that spin-polarized IXs created using a circularly polarized laser beam diffuse up to distances 15 μm away from the generation point, revealing spatial oscillations of the polarization degree ρ_z. The latter are attributed to the precession of the spin vector in the spin-orbit effective magnetic field B$_{SO}$ as they move away from the excitation spot, which can be modulated both with electric and magnetic fields. The IXs spin transport using acoustic fields is also discussed.

[1] J. R. Leonard, Y. Y. Kuznetsova, S. Yang, L. V. Butov, T. Ostatnick, A. Kavokin, and A. C. Gossard. Nano Lett. 9, 4204-4208 (2009)

MA 41.4 Thu 10:45 POT 151

Time- and space-resolved measurements of spin diffusion in high-mobility GaAs-based 2D electron systems — •Markus Schwemmer[1], Roland Voelkl[1], Tobias Korn[1], Sergey Tarasenko[2], Dieter Schuh[1], Werner Wegscheider[3], and Christian Schüller[1] — [1]Institute of Experimental and Applied Physics, Faculty of Physics,University of Regensburg, Germany — [2]A. F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia — [3]ETH Zurich, Switzerland

Two-dimensional electron systems embedded in (110)-grown, symmetrically doped GaAs/AlGaAs QWs are highly interesting for spintronics. They combine high carrier mobility with long spin dephasing times. Previously, we have studied these systems in different experiments, which either gave temporal or spatial resolution. By using a two-beam Hanle-MOKE method we could observe diffusion lengths of more than 125 μm at low temperatures. As a next step, the experimental setup was modified in order to achieve temporal and spatial resolution with the help of a single pulsed TiSa laser. The main issue is the spectral separation of the pump and the probe beams, which are collinearly focused onto the sample. Due to the broad spectrum of the femtosecond laser pulse, this can be realized using bandpass filters. Besides the mapping of the temporal propagation of the spins via diffusion, this experimental setup should also allow to visualize the evolution of a drifting spin packet. Financial support by the DFG via SFB 689 and SPP 1285 is gratefully acknowledged.

MA 41.5 Thu 11:00 POT 151

Direct measurement of the spin splitting in GaAs quantum wells — •Christoph Schönhuber[1], Matthias Walser[2], Christian Reichl[3], Werner Wegscheider[3], Gian Salis[2], Tobias Korn[1], and Christian Schüller[1] — [1]Universität Regensburg, 93040 Regensburg, Germany — [2]IBM Research-Zurich, 8803 Rüschlikon, Switzerland — [3]ETH Zurich, 8093 Zurich, Switzerland

We investigate the spin splitting in the conduction band of GaAs quantum wells employing Raman scattering experiments. The investigated system consists of a 12-nm-wide (001)-oriented GaAs/AlGaAs QW, which is asymmetrically Si modulation doped to reach a balanced Rashba and Dresselhaus SOI contribution.

The performed measurements on intrasubband transitions reveal a double peak structure for the [11] direction, while in [1-1] direction there is only a single peak. This anisotropic behavior in the spin splitting is probed for a wide range of transfered wavevectors and in good agreement with the prediction for a system with comparable magnitudes of Rashba and Dresselhaus SOI.

MA 41.6 Thu 11:15 POT 151

Hole g-factor anisotropy in coupled GaAs/AlAs quantum wells — •Christian Gradl, Michael Kempf, Dieter Schuh, Dominique Bougeard, Christian Schüller, and Tobias Korn — Universität Regensburg, D-93040 Regensburg, Germany

We performed time-resolved Kerr rotation measurements on undoped [110]- and [113]-grown double quantum well (QW) structures to resolve the spin dynamics of hole ensembles at low temperatures. For these growth directions, a strong anisotropy of the hole g-factor with respect to the in-plane magnetic field direction is theoretically predicted.

Our gated system consists of two QWs with different well widths, which we use for the spatial separation of the optically excited electron-hole pairs. Thus, we are able to create hole ensembles with spin lifetimes of several hundreds of picoseconds in the broader QW without any doping. This also allowed an observation of a strong hole g-factor anisotropy by varying the magnetic field direction in the QW plane. Moreover, our extracted values are in a very good agreement with theoretical predictions.

MA 41.7 Thu 11:30 POT 151

Polarization oscillations in spin-polarized vertical-cavity

surface-emitting lasers controlled by multiple excitation pulses — •Henning Höpfner, Markus Lindemann, Nils C. Gerhardt, and Martin R. Hofmann — Photonics and Terahertz Technology, Ruhr-University Bochum, D-44780 Bochum, Germany

Spin-polarized lasers offer many potential advantages over their conventional counterparts, including threshold reduction, polarization control and ultrafast dynamics for increased modulation bandwidth [1].

Upon excitation with circularly polarized light that creates spin-polarized carrier in a vertical-cavity surface-emitting laser (VCSEL), the VCSEL shows oscillations of the circular polarization degree. These polarization oscillations can be much faster than the relaxation oscillations of the carrier-photon system. From calculations based on a rate-equation model we show that these oscillations can be switched on and off in a controlled manner using multiple circularly polarized optical excitation pulses. The results are verified experimentally, showing spin-induced polarization oscillation in conventional, electrically biased VCSELs subject to optical spin injection. We show polarization oscillation bursts with possible modulation frequencies far beyond the device's electrical modulation bandwidth.

[1] Gerhardt et al., Applied Physics Letters 99 (15), 151107 (2011)

MA 41.8 Thu 11:45 POT 151

Spin polarization of electron states in GaAs quantum wells — •Pavel Streda — Institute of Physics ASCR, Praha, Czech Republic

The standard method to establish the spin orientation of electron states, for zinc-blende semiconductors like GaAs, is based on the effective medium approach represented by the Luttinger Hamiltonian. For a two-dimensional electron gas, confined within a potential well, the real eigenfunctions of bound states across the well has been approximated by an envelope function. It leads to the conclusion that along main crystallographic axis, $[1,0,0]$ and $[0,1,0]$, the spin orientation is parallel or antiparallel with velocity directions. This contradicts to the tendency of the spin to be perpendicular to the velocity direction, observed in bulk structures.

The question arises if an envelope function approach, which suppresses the effect of local environment, is not too crude approach for real quantum wells, which are usually wider than ten lattice constants. To answer this question the empirical pseudopotential method has been used to establish energy dispersions and spin expectation values for two-dimensional electron gas confined within quantum wells of the different width. In all cases the tendency of the spin to be perpendicular to the velocity direction has been observed. For wide enough wells the obtained spin structure approaches that given by the bulk GaAs crystal with $k_z = 0$.

MA 41.9 Thu 12:00 POT 151

Spin injection efficiency dependence on MgO tunnel barrier thickness — •Lennart-Knud Liefeith, Tomotsugu Ishikura, Zhixin Cui, and Kanji Yoh — Research Center for Integrated Quantum Electronics, Japan

We study non-local spin valves in inverted InAlAs/InGaAs high-electron mobility transistors on InP(001). On the ferromagnet (FM) side, permalloy electrodes are employed. On the semiconductor (SC) side the electron system resides in a two-dimensional InAs channel. It has been argued that direct FM/SC contacts provide negligible spin polarization in the SC if the transport is diffusive, known as the conductivity mismatch problem[1]. In the ballistic transport regime efficient spin injection is predicted[2]. For devices basing on ballistic transport, a low contact resistance between FM and SC is essential. An strategy to tackle the conductivity mismatch problem is the insertion of a tunnel barrier at the FM/SC interface. We thus study ballistic structures with MgO tunnel barriers of varied thickness. Here we will compare spin injection efficiencies in non-local spin valve structures with either no or a 2 nm-thick MgO tunnel barrier at the FM/SC interface.

[1] G. Schmidt, „Fundamental obstacle for electrical spin injection from a ferromagnetic metal into a diffusive semiconductor“, Physical Review B 62, R4790 (2000)
[2] M. Zwierzycki, „Spin-injection through an Fe/InAs interface“, Physica Status Solidi A: Applications and Materials Science 1, 25-28 (2003)

MA 42: Magnetic Materials III

Time: Thursday 15:00–18:15 Location: HSZ 04

MA 42.1 Thu 15:00 HSZ 04

Stabilization of a structural pattern by local magnetic exchange in MnPtSi — Sarah Ackerbauer, •Andreas Leithe-Jasper, Walter Schnelle, Helge Rosner, and Yuri Grin — Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Straße 40, 01187 Dresden

Among the inorganic materials in general and intermetallic compounds in particular, the ternary phases with the stoichiometric ratio 1:1:1 belong to one of the largest families. The Pearson's Crystal Data - Crystal Structure Database for Inorganic Compounds counts several hundreds of the equiatomic phases. Despite a relatively simple component ratio more than 15 structure types have been found for the compounds of this group. This - on the first glance unexpected finding - is directly connected with the mechanisms of chemical bonding in intermetallic compounds. A possible scenarios may be described by two different energy scales: On the larger scale, an atomic arrangement is formed by combination of covalent and ionic interactions in accordance with the electronic needs of constituting elements. The final tuning of the structure is performed at a smaller scale and includes additional atomic interactions. In particular, paramagnetism of the components can be decisive for the achieving of the minimum of the total energy in the second step. The analysis of chemical bonding in MnPtSi reveals that the local magnetism of Mn rules its finally adopted structure.

MA 42.2 Thu 15:15 HSZ 04

Quantum oscillations and high carrier mobility in the delafossites PdCoO2 and PdCrO2 — •Clifford Hicks[1,2], Alexandra Gibbs[1], Andrew Mackenzie[1,2], Hiroshi Takatsu[3,4], Yoshiteru Maeno[4], and Edward Yelland[1] — [1]University of St Andrews, St Andrews, United Kingdom — [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [3]Tokyo Metropolitan University, Tokyo, Japan — [4]Kyoto University, Kyoto, Japan

We present torque magnetometry and resistivity data on single crystals of the delafossites $PdCoO_2$ and $PdCrO_2$. At 295 K we measure an in-plane resistivity of 2.6 $\mu\Omega$-cm in $PdCoO_2$, making it the most conductive oxide known. $PdCrO_2$ has the same crystal structure as $PdCoO_2$, but is a triangular antiferromagnetic metal. Apart from the addition of the magnetism, the electronic structure of $PdCrO_2$ is strikingly similar to that of $PdCoO_2$, and comparison of these two metals provides an opportunity to isolate the effects of the magnetism.

MA 42.3 Thu 15:30 HSZ 04

Angle-resolved photoemission spectroscopy on iron-chalcogenide superconductors — •Janek Maletz[1], Volodymyr Zabolotnyy[1], Daniil Evtushinsky[1], Setti Thirupathaiah[1], Anja Wolter-Giraud[1], Luminita Harnagea[1], Alexander Yaresko[3], Alexander Vasiliev[4], Dimitri Chareev[5], Emile Rienks[6], Bernd Büchner[1,2], Alexander Kordyuk[1], Zurab Shermadini[7], Hubertus Luetkens[7], Kamil Sedlak[7], Rustem Khasanov[7], Alex Amato[7], Anna Krzton-Maziopa[7], Kazimierz Conder[7], Ekaterina Pomjakushina[7], Hans-Henning Klauss[2], and Sergey Borisenko[1] — [1]IFW Dresden — [2]TU Dresden — [3]MPI-FKF, Stuttgart — [4]Moscow State University — [5]RAS, Chernogolovka, Russia — [6]Helmholtz-Zentrum Berlin — [7]Paul Scherrer Institute, Switzerland

The electronic structure of the iron chalcogenide superconductors $FeSe_{1-x}$ and $Rb_{0.77}Fe_{1.61}Se_2$ was investigated by high-resolution angle-resolved photoemission spectroscopy (ARPES). The results were compared to DFT calculations and μSR measurements. Both compounds share "cigar-shaped" Fermi surface sheets in their electronic structure, that can be found in almost all iron-pnictide superconductors. These features originate from a strong interplay of two hole- and electron-like bands in the Brillouin zone center, leading to a pronounced singularity in the density of states just below the Fermi level. This faciliates the coupling to a bosonic mode responsible for superconductivity. This work was supported by the DFG Schwerpunktprogramm 1458 (BO1912/3-1 and BO1912/2-2).

MA 42.4 Thu 15:45 HSZ 04

Spin-liquid phase and order-by-disorder on the frustrated swedenborgite-lattice — •Stefan Buhrandt[1] and Lars Fritz[2] — [1]Institut für theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany — [2]Institute for Theoretical Physics, Utrecht University, Leuvenlaan 4, 3584 CE Utrecht, The Netherlands

The phenomenon of frustration refers to the inability to satisfy competing interactions simultaneously. Often, strong frustration leads to a large number of degenerate ground states with fluctuations suppressing the ordering tendencies. A challenging task is to characterize the spin-liquid phase resulting from the inability to order and the eventual breaking of ground state degeneracy. While this is usually accomplished by small perturbations, an intrinsic effect is entropic order-by-disorder. We present evidence that a classical nearest-neighbor Heisenberg model on the swedenborgite lattice hosts both an extended spin-liquid phase as well as a version of entropic order-by-disorder taking place at very low temperatures. We argue that this observation renders magnetic insulators on the swedenborgite lattice a prime candidate for displaying spin liquid and order-by-disorder physics.

MA 42.5 Thu 16:00 HSZ 04

Long range incommensurable spin ordering in a swedenborgite compound — •Johannes Reim[1], Martin Valldor[2], and Werner Schweika[1] — [1]Jülich Centre for Neutron Science JCNS-2 and Peter Grünberg Institut PGI-4, Forschungszentrum Jülich, Jülich, Germany — [2]II. Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

The new swedenborgite compound family (P6$_3$mc) displays similarly to the pyrochlores a highly frustrated network of tetrahedral coordinated magnetic ions. However, its broken inversion symmetry raises further the complexity of ordering due to non-vanashing DM interactions. Recently investigated materials of this family show various signs for unusual geometric frustration. In compounds with magnetic Co and Fe ions, where single crystals are available like $CaBaCo_2Fe_2O_7$, we observed an antiferromagnetic ordering below $T_N \approx 160\,K$, which, however, turned out to be rather complex. Diffuse neutron scattering at DNS (FRM II) has revealed a magnetic order in a three times larger supercell. A particular intriguing result was the chiral interference observed apparently as an asymmetry of the magnetic Bragg intensities. Further powder diffraction experiments at POWGEN (SNS) with higher resolution evidenced additional satellite peaks close to the main magnetic peaks, with a propagation vector $\tau = 0.016\,\text{Å}^{-1}$ corresponding to a long periodicity of about 400 Å.

15 min. break

MA 42.6 Thu 16:30 HSZ 04

Theoretical investigations on the phase diagram of Cr-Sb and Cr-V-Sb — •Gerhard Kuhn[1], Svitlana Polesya[1], Sergiy Mankovsky[1], Hubert Ebert[1], Matthias Regus[2], and Wolfgang Bensch[2] — [1]Ludwig-Maximilians-Universität München — [2]Christian-Albrechts-Universtität zu Kiel

Investigations on the phase diagram of Cr-Sb, especially Cr_3Sb have been performed, using the Munich KKR package, that combines density functional theory (DFT) with an all electron Green's function (GF) method. Nonstoichiometric systems have been dealt with by means of the coherent potential approximations (CPA). To investigate temperature dependent magnetic properties Monte Carlo (MC) simulations based on the exchange coupling constants J_{ij} calculated by Lichtenstein's formula have been performed.

While the Cr_3Si-structure, that is assumed to be the ground state, is a simple paramagnet, different possible meta-stable structures, especially the Cr_3Sb DO3 phase and the Heusler-like Cr_2VSb phase, show interesting half-metallic behavior. It can be shown, that in both cases the magnetic moments behave according to the Slater-Pauling-rules. Calculations show that the half-metalicity as well as the Slater-Pauling behavior is destroyed for V_2CrSb and V_3Sb. The ferri-magnetic order of the system can be explained by the anti-ferromagnetic interactions between Cr-atoms with different spin. The critical Temperatures T_C have been calculated for different lattice constants. In addition the Gilbert damping parameter have been calculated for the investigated system.

MA 42.7 Thu 16:45 HSZ 04

Small damping parameters in Co_2FeSi and Fe_2CoSi films — •Christian Sterwerf[1], Markus Meinert[1], Jan-Michael Schmalhorst[1], Behrouz Khodadadi[2], Soumalya Paul[2], Matthias Buchmeier[2], Claudia Mewes[2], Tim Mewes[2], and Günter Reiss[1] — [1]Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, 33501 Bielefeld, Germany — [2]Department of Physics and Astronomy/MINT Center, University of Alabama, Tuscaloosa, Alabama 35487, USA

Co and Fe based Heusler compounds are promising candidates for spintronic devices as they offer high Curie temperatues and high spin polarizations.

In an earlier publication we presented sputtered $Co_{2-x}Fe_{1+x}Si$ ($0 \leq x \leq 1$) films with good crystalline ordering and high tunnel magnetoresistance (TMR) ratios in magnetic tunnel junctions (MTJs) with a $Co_{2-x}Fe_{1+x}Si$ electrode. [1]

Magnetization relaxation and the anisotropy of the films were determined by broadband ferromagnetic resonance (FMR) and magnetooptical Kerr effect (MOKE) measurements. With the help of a broadband FMR and the consideration of the extrinsic linewidth, very small damping parameters were found. The damping parameter for Co_2FeSi is 0.002.

[1] Sterwerf, Christian, et al. "High TMR Ratio in Co_2FeSi and Fe_2CoSi based Magnetic Tunnel Junctions." *IEEE Transactions on Magnetics* 49.7 (2013): 4386.

MA 42.8 Thu 17:00 HSZ 04

Element resolved atomic vibrational properties of magnetocaloric $LaFe_{13-x}Si_x$ — •Markus Ernst Gruner[1,2], Werner Keune[2,3], Beatriz Roldan Cuenya[4], Joachim Landers[2], Sergey Makarov[2], David Klar[2], Michael Y. Hu[5], Ercan E. Alp[5], Maria Krautz[1], Oliver Gutfleisch[6], and Heiko Wende[2] — [1]IFW Dresden — [2]Universität Duisburg-Essen — [3]MPI Halle — [4]Ruhr-Universität Bochum — [5]Argonne National Laboratory — [6]TU Darmstadt

Large magnetocaloric effects are obtained at discontinuous magnetic phase transitions, which are preferentially close to second-order as this keeps hysteresis losses small. In $LaFe_{13-x}Si_x$, the first order character is connected with a significant volume decrease upon disordering the magnetic subsystem, arising from the coupling of magnetic and elastic degrees of freedom. Their contribution to the total entropy change is thus not necessarily cooperative. By comparing nuclear resonant inelastic X-ray scattering (NRIXS) with a sample with 10 % ^{57}Fe isotopic enrichment ($x = 1.4$) and extensive DFT modeling ($x = 1.5$) we obtain the element and site-resolved phonon density of states in the ordered and the paramagnetic state. These allow us to understand the impact of magnetoelastic interactions on the vibrational entropy change at the magnetic phase transition.

MA 42.9 Thu 17:15 HSZ 04

Study of the magnetocaloric effect in MnFe4Si3 — •Paul Hering[1], Karen Friese[1], Jörg Voigt[1], Thomas Brückel[1], Anatoliy Senyshyn[2], Nadir Aliouane[2,3], and Andrzej Grzechnik[4] — [1]JCNS-2/PGI 4, Forschungszentrum Jülich — [2]MLZ, TUM, Garching — [3]PSI, Villigen, Schweiz — [4]Inst. of Crystallo., RWTH Aachen

Due to global warming, there is an increasing demand for more energy-efficient refrigeration technologies. Magnetocaloric devices are candidates to replace conventional vapor compression cooling, as they have potentially 20-30% lower energy consumption. MnFe4Si3 is a promising candidate for magnetic cooling at ambient temperatures [Songlin, et. al., J. Alloys Comp. 334, 249 (2002)]. To understand the interplay of the spin and lattice degrees of freedom in this material, we studied the magnetic properties and the temperature dependent evolution of its hexagonal structure. The compound undergoes a magnetic phase transition close to 300K, which is accompanied by a modestly high magnetocaloric effect (MCE) of 2.9 J/kg K at a magnetic field change from 0T to 2T. Refinements with the program Jana2006 using single crystal neutron and x-ray data simultaneously show that in the ferromagnetically ordered structure the magnetic moments are aligned in the a,b-plane. Magnetic susceptibility measurements confirm the easy axis of magnetization perpendicular to the c-axis. Lattice parameter obtained from neutron powder diffraction data show a discontinuous change at the temperature of the onset of magnetic ordering. This clearly indicates the first order character of the phase transition and explains the relatively high MCE.

MA 42.10 Thu 17:30 HSZ 04

Direct measurement of the magnetocaloric effect in $La(Fe,Si,Co)_{13}$ compounds in pulsed magnetic fields — •M. Ghorbani[1,2], Y. Skourski[1], K.P. Skokov[3], M.D. Kuz'min[3], O.

Gutfleisch[3], and J. Wosnitza[1,2] — [1]Hochfeld-Magnetlabor Dresden (HLD), Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden — [2]Institut für Festkörperphysik, TU Dresden, 01069 Dresden, Germany — [3]Institut für Materialwissenschaft, TU Darmstadt, Germany

We report on direct measurements of the magnetocaloric effect (MCE) of La(Fe,Si,Co)$_{13}$ compounds, which are promising candidates for magnetic refrigeration applications as they undergo a metamagnetic transition associated with substantial entropy change. The nature of the transition can be changed from first to second order. Further, the temperature of the transition is tunable by varying the Co concentration. We have measured the MCE for two compounds with different Co concentrations with transition temperatures of 199 K (first order) and 254 K (second order). At low fields the former compound shows a higher MCE, but at the maximum field of 50 Tesla both compounds yield similar temperature changes of about 15 K.

MA 42.11 Thu 17:45 HSZ 04

Magnetic and magnetocaloric properties of the MnB system — •Maximilian Fries, Konstantin Skokov, and Oliver Gutfleisch — TU Darmstadt, Materialwissenschaften, 64287 Darmstadt

Magnetocalorics is a thriving research topic and materials that exhibit this effect become of high demand in case magnetic cooling can one day replace conventional refrigeration technologies. Especially materials with critical elements like rare earths, for example the reference material Gadolinium, are relevant in this field. To overcome this problem a lot of research is focused on finding materials which exhibit a magnetic transition (e.g. FM to PM) coupled to a structural transition at the desired transition temperature containing no critical elements. Such developments will reduce both raw material use and future technology cost. Here we report on the magnetic and structural properties of the compound MnB which undergoes a FM to PM transition at about 570K with minimal hysteresis, exhibiting an entropy change of 7 J/kgK in a field change of 0-2T. Furthermore we show results on the substitution in the compound MnxB in order to tune the Curie temperature and the magnetocaloric properties in this material system.

MA 42.12 Thu 18:00 HSZ 04

First-principles simulation of the instability leading to giant magnetocaloric effects — •Peter Entel, Markus Gruner, and Anna Grünebohm — Faculty of Physics and CENIDE, University of Duisburg-Essen, 47048 Duisburg

Ferroic cooling using magnetic solids may lead to a technological breakthrough in future cooling devices. In particular magnetic Heusler alloys such as Ni-Co-Mn-(Ga, In, Sn), and La-Fe-Si, Ga-Mn-C-N and Fe-P based alloys have proven to be suitable for magnetic refrigeration besides the ternary compound Gd-Ge-Si showing giant magnetocaloric effect (MCE). Here, we will address the important aspect of the sudden drop of the magnetization from the ferromagnetic to an antiferromagnetic/paramagnetic state near the magnetostructural transition which is responsible for the giant inverse MCE in some of these systems. We employ density functional theory (DFT) together with finite-temperature Monte Carlo (MC) simulations in the investigations showing that the size of the jump of magnetization in external magnetic fields defines the MCE. Adding elements like Co to the ternary compounds, which is accurately handled in the DFT and MC simulations, allows to explore optimization of the MCE.

MA 43: Magnetization Dynamics III

Time: Thursday 15:00–18:15 Location: HSZ 401

MA 43.1 Thu 15:00 HSZ 401

Magneto-elastic modes and magnon lifetime in thin yttrium-iron garnet films — •Andreas Rückriegel[1,2] and Peter Kopietz[1,2] — [1]Institut für Theoretische Physik, Universität Frankfurt — [2]Department of Physics, University of Florida

We calculate the effect of the spin-lattice coupling on the magnon spectrum of thin films of the magnetic insulator yttrium-iron garnet. We show that the hybridisation between phonons and magnons generates characteristic phonon peaks in the magnon spectral function and give explicit expressions for the spectral weight of these peaks. We also derive the interaction vertices between magnons and phonons and estimate the resulting phonon contribution to the magnon life-time at room temperature.

MA 43.2 Thu 15:15 HSZ 401

Spin Dephasing and Magnetization Damping due to electron-phonon scattering in a ferrimagnetic s-d model — Alexander Baral and •Hans-Christian Schneider — University of Kaiserslautern and Research Center OPTIMAS

We calculate the spin dynamics in a model of itinerant carriers coupled antiferromagnetically to a macrospin ("ferrimagnetic s-d model") due to the coupling to a phonon bath in the presence of spin-orbit coupling. Using a mean-field approximation for the s-d model, we derive Boltzmann scattering integrals for the distributions and spin coherences for the case of a antiferromagnetic exchange splitting, which is complicated by dynamical changes of the longitudinal and transversal magnetization directions. We assume the spin-orbit coupling to be of the Rashba form so that the resulting model describes a form of Elliot-Yafet type electron-phonon scattering within an equation of motion formalism. We extrapolate dephasing- and magnetization times and draw a comparison to phenomenological equations such as Landau-Lifshitz (LL) [1] or Landau-Lifshitz-Gilbert (LLG) [2]. We then analyze the magnetization precession and relaxation of the antiferromagnetically coupled carrier spins and macrospin in an anisotropy field [3] and find a carrier mediated dephasing of the macrospin via mean-field coupling.

[1] L. D. Landau and E. M. Lifshitz, Phys. Z. Sowjet., vol. 8, pp. 153-169 (1935).
[2] T. L. Gilbert, IEEE Transactions on Magnetics, vol. 40(6), pp. 3443-3449 (2004).
[3] Y.Tserkovnyak, Applied Phys. Lett Vol.84, Number 25 (2004).

MA 43.3 Thu 15:30 HSZ 401

Nonlinear spin-wave scattering in a micro-structured magnonic crystal — Björn Obry[1], •Thomas Meyer[1], Philipp Pirro[1], Thomas Brächer[1,2], Julia Osten[3], Andrii V. Chumak[1], Alexander A. Serga[1], 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 Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany, and TU Dresden, 01062 Dresden, Germany

We study the nonlinear multi-magnon processes in a micro-structured magnonic crystal consisting of a $Ni_{81}Fe_{19}$ waveguide, which has been periodically modulated in its saturation magnetization by localized ion implantation. A significant modification of the nonlinear magnon spectrum compared to a reference waveguide is determined, exhibiting a predominant scattering into modes with a frequency at the magnonic band gaps and an enhancement of the nonlinearities for some excitation frequencies. The results prove the feasibility to utilize nonlinear multi-magnon scattering for magnon spintronic applications on the micrometer scale.

MA 43.4 Thu 15:45 HSZ 401

Spin wave mediated synchronization of localized modes in spin torque nano-oscillators — •Thomas Kendziorczyk and Tilmann Kuhn — Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Spin torque nano-oscillators (STNOs) are promising candidates for tunable nanoscale microwave sources for applications in chip-to-chip and wireless communications. In 2005 it has been demonstrated experimentally [1], that two STNOs can be synchronized, which can greatly increase their output power. The synchronization of the STNO pair was realized by mutual interaction through propagating spin waves. However this experiment has been performed for an out-of-plane magnetized magnetic film, which requires impractical high external magnetic fields. In this contribution we will show by means of micromagnetic modeling how to achieve long-range synchronization between STNOs which are placed on an in-plane magnetized magnetic film. While requiring much lower external fields, usually the excited modes for STNOs in this geometry are self-localized. However, it is possible through the local modification of the internal field to increase the frequency of the STNO above the FMR of the surrounding film, which promotes emission of spin waves [2]. We predict, that two such localized modes which are coupled by spin waves in the surrounding material can be used for a long-range synchronization through the emission of directional spin waves.

1. S. Kaka et al., Nature 437, 389 (2005)
2. H. Ulrichs et al., Appl. Phys. Lett. 100,16 (2012)

MA 43.5 Thu 16:00 HSZ 401

Spin waves in ultrathin hexagonal Cobalt films — •Eugen Michel[1,2], Jayaraman Rajeswari[1,2], Harald Ibach[1,2], and Claus M. Schneider[1,2] — [1]Peter-Grünberg-Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Jülich Aachen Research Alliance, Germany

As previous publications [1,2] have shown electron energy loss spectroscopy is a promising tool for studies of large wave vector spin waves in the surface and thin film region. Using our high-resolution spectrometer [3] we have probed the dispersion of spin waves in hexagonal Co-films grown on Cu(111) and Au(111) single crystal surfaces. The film thicknesses ranged from 3 to 18 atomic layers (AL). For Co grown on Cu(111) we have observed surface spin wave signatures with wave vectors in the range of q = 2 - 8 1/nm. Furthermore we have resolved standing wave modes for film thicknesses between 3AL and 5AL. The results are compared to theoretical calculations based on the Heisenberg model with adjusted exchange coupling constants. The spin wave spectra from films grown on Au(111) exhibit a significant broadening, which is attributed to the higher disorder of the Co-films. The spectra can be simulated taking the experimentally determined wave vector resolution into account.

[1] R. Vollmer et al., JMMM 272-276, (3), pp 2126-2130 (2004).
[2] J. Rajeswari et al., Phys. Rev. B 86, 165436 (2012).
[3] H. Ibach et al., JESRP 185, 3 - 4, pp 61-70 (2012).

MA 43.6 Thu 16:15 HSZ 401

Standing spin waves in thin magnetic films: A method to test for layer-dependent exchange coupling — •Jayaraman Rajeswari, Harald Ibach, and Claus M. Schneider — Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany

We present an experimental method for probing the layer dependence of exchange coupling constants in thin magnetic films. The method is based on the simultaneous observation of standing spin waves with a single node inside the film and surface spin waves of the film using the technique of inelastic electron scattering. Experimental data are shown for 5-8 layers of fcc cobalt deposited on Cu(100). The data are compared to theoretical studies predicting a strong enhancement of the exchange coupling constants at the surface and the interface and even oscillations near surface and interface. Neither one fits the experimental data per se, while a simple nearest neighbor Heisenberg model with uniform exchange coupling does. We therefore conclude a small depth dependence of the exchange coupling between atoms.

15 min. break

MA 43.7 Thu 16:45 HSZ 401

Condensation of mixed magnon-phonon states below the bottom of the magnon spectrum — •Dmytro A. Bozhko[1], Alexander A. Serga[1], Peter Clausen[1], Vitaliy I. Vasyuchka[1], Andrii V. Chumak[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

The Brillouin light scattering technique is used to measure the distribution of a parametrically driven magnon gas in frequency and wavevector spaces. The experiment is performed utilizing an in-plane magnetized 6.7 μm thick single-crystal yttrium iron garnet film. A magnetizing field is tuned to excite the parametric magnons at the ferromagnetic resonance frequency of 6.8 GHz. In the case of a quasi-uniform pumping field, we are able to detect a strong magnon density peak around the bottom of the spin waves spectrum (4.8 GHz) at the hybridization area ($8 \cdot 10^4$ rad/cm) between a backward volume magnetostatic wave and a transverse acoustic wave. This peak is understood as the condensation of magnon-phonon quasi-particles at a virtual energy minimum, whose frequency position is determined by magnon-phonon interaction. It is remarkable that no condensation is observed in the spatially localized pumping field: The magnon-phonon quasi-particles have a very high group velocity, and thus leave the thermalization area. Financial support by the DFG within the SFB/TR 49 is gratefully acknowledged.

MA 43.8 Thu 17:00 HSZ 401

Thermalization and Bose-Einstein condensation of magnons — •Julian Hüser and Tilmann Kuhn — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

In 2006 Demokritov and co-workers observed clear evidence for room temperature Bose-Einstein condensation of magnons [1]. The BEC threshold was reached by increasing the magnon density by means of parametric pumping. The pumped magnons quickly redistributed over the spin wave spectrum and a macroscopic fraction finally accommodated the dispersion minimum leading to Bose-Einstein condensation.

Nevertheless, from the theoretical point of view the role of the different types of interaction processes among the magnons themselves and between magnons and phonons are still not well understood.

In this work we analyze the nonequilibrium dynamics of the hot magnon gas and the time evolution of the condensate by solving the quantum Boltzmann equation. We investigate the various types of interaction between magnons and phonons which can be grouped into two classes. The first type leads to a relaxation of the magnetic system whereas the second type keeps the magnon number constant thus only leading to an energy relaxation. We show that the latter interaction even enhances the condensate under certain conditions.

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[1] S. O. Demokritov, V. Demidov, O. Dzyapko, G. A. Melkov, A. A. Serga, B. Hillebrands, and A. N. Slavin, Nature 443, 430 (2006)

MA 43.9 Thu 17:15 HSZ 401

Time-resolved imaging of isolated confined spin-wave packets — •Philipp Wessels[1], Marek Wieland[1], Jan-Niklas Tödt[2], and Markus Drescher[1] — [1]Institute for Experimental Physics, University of Hamburg, Germany — [2]Institute of Applied Physics, University of Hamburg, Germany

We present spatially and temporally resolved measurements on the dynamics of isolated spin-wave packets created by a short, broadband current pulse. The time evolution of the magnetization in confined magnetic media is analyzed by a time-resolved scanning Kerr microscope (TR-SKM) via the magneto-optic Kerr effect (MOKE) in combination with femtosecond laser pulses to carry out stroboscopic pump-probe experiments.

With a novel pump approach utilizing a magnesium photocathode as electro-optical switch, the generation of intense electronic current pulses becomes possible for excitation of magnetic systems with the transported transient magnetic field. The available master laser pulses of 1030 nm wavelength and 290 fs duration are doubled in frequency to obtain probe pulses of 515 nm wavelength which are further converted into UV pump pulses of 258 nm wavelength by another frequency doubling stage to drive the photocathode.

This enables jitter-free measurements on isolated spin-wave packets in permalloy ($Ni_{80}Fe_{20}$) microstructures with a temporal resolution $<$ 10 ps and a spatial resolution $<$ 670 nm FWHM. The spatially and temporally resolved data set permits a direct observation and global analysis of the dynamic parameters defining the wave-packet.

MA 43.10 Thu 17:30 HSZ 401

Material engineering for all-optical switching — •Ute Bierbrauer[1], Stéphane Mangin[2,3], Matthias Gottwald[3], Charles-Henri Lambert[2,3], Daniel Steil[1], Vojtech Uhlíř[3], Lin Pang[4], Michel Hehn[2], Sabine Alebrand[1], Mirko Cinchetti[1], Stefan Mathias[1], Grégory Malinowski[2,5], Yeshaiahu Fainman[4], Eric E. Fullerton[3,4], and Martin Aeschlimann[1] — [1]University of Kaiserslautern, Germany — [2]Institute Jean Lamour, Université de Lorraine, France — [3]Center for Magnetic Recording Research, San Diego, USA — [4]University of California San Diego, USA — [5]Laboratoire de Physique des Solides, Université Paris-Sud, France

Since the discovery of all-optical switching (AOS) in ferrimagnetic rare-earth transition metal (RE-TM) alloy films [1,2] the question arose if a manipulation of magnetic order without applying magnetic fields is also possible in engineered ferrimagnetic materials without rare-earth-elements.

Here we demonstrate that AOS can also be observed in more complex systems, including multilayer structures and synthetic ferrimagnetic hetero-structures. Furthermore we show the magnetization dynamics of these materials, particularly with a closer view on the magnetization reversal occurring on the ultrafast timescale. The presented results open a new pathway to engineering materials for future applications based on all-optical control of magnetic order and show new insights about the phenomenon of AOS.

[1] C.D. Stanciu et al., PRL 99, 047601 (2007)
[2] S. Alebrand et al., APL 101, 162408 (2012)

MA 43.11 Thu 17:45 HSZ 401

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

Magnetic linear dichroism in the angular distribution of photoelectrons (MLDAD) is a technique that allows the study of both the electronic band structure and the magnetic properties of thin films and single crystals. We are looking for a deeper understanding of the magnetic linear dichroism of 3d metals, specifically which parts of the band structure are responsible for this phenomenon. In this study linearly polarized synchrotron radiation (Beamline 5, DELTA Dortmund) in the VUV regime is used. The studied system is an epitaxially grown hcp(0001) Co thin film on a W(110) surface.

The electronic structure of the valence band is measured by variation of the photon energy. At lower energies, dichroism measurements are confirmed [1] and extended to angle-resolved spectra in off-normal geometry. These angle-resolved measurements present opposite effects for positive and negative detection angles. At 60 eV photon energy we observe a resonance between the Co 3p and the valence band which influences the dichroism.

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

MA 43.12 Thu 18:00 HSZ 401

A sensor layer to magnify the magnetic vortex core polarization — •Georg Dieterle[1], Joachim Gräfe[1], Matthias Noske[1], Markus Sproll[1], Ajay Gangwar[1,2], Markus Weigand[1], Hermann Stoll[1], Georg Woltersdorf[2], Christian H. Back[2], and Gisela Schütz[1] — [1]MPI for Intelligent Systems, Stuttgart, Germany — [2]Department of Physics, Regensburg University, Germany

Sophisticated techniques like synchrotron based X-ray microscopy have to be used for imaging the vortex core (which can point either up or down) in magnetic vortex structures. We show how to magnify the vortex core magnetization to a diameter in the micrometer range in order to detect its polarization with magneto-optical Kerr effect (MOKE) microscopy. This can be achieved by a GdFe multilayer with out-of-plane magnetization and very low coercivity on top of a Permalloy vortex structure. The vortex core in the Permalloy disc is switched unidirectionally by a rotating RF magnetic field burst at the gyromode frequency of the vortex structure (about 570 MHz in our samples) with an amplitude A and a duration L. The reversal of the vortex core polarization by this RF burst also causes a defined reversal of the out-of-plane magnetization of the whole GdFe layer, 500 nm in diameter, which now can be easily detected by MOKE microscopy. Therefore, the GdFe layer acts as a sensor layer to magnify the polarization of the tiny vortex core. Experimental data are reported on the amplitude A and the duration L of the rotating RF fields necessary to switch both, (i) the vortex core polarization in the Permalloy disc and (ii) the magnetization of the whole GdFe disc above the vortex structure.

MA 44: Spin Torque and Spin Excitations II

Time: Thursday 15:00–16:30 Location: HSZ 403

MA 44.1 Thu 15:00 HSZ 403

First-principles determination of spin-orbit torques within relativistic KKR — Diemo Ködderitzsch, Marten Seemann, Sergiy Mankovskyy, and •Hubert Ebert — Universität München, Dept. Chemie, Butenandtstraße 5-13, D-81377 München, Germany

The prediction and experimental observation of torques acting on the magnetization due to an applied electric field induced by spin-orbit interaction and broken inversion symmetry has recently attracted a lot of interest.[1,2] Employing a recent Kubo-Bastin-like formulation for the determination of spin-orbit torques [3] we here present a fully relativistic implementation within the KKR first-principles electronic structure method. The matrix elements for the torkance-current correlation functions are calculated in a similar manner as those occurring in transverse transport and the Gilbert damping.[4,5] A symmetry analysis of the occurring torque terms is given. Applications to disordered systems will illustrate the approach.

[1] Manchon, Zhang, PRB **78**, 212405 (2008); [2] Gambardella, Miron, Phil. Trans. R. Soc **369**, 3175 (2013); [3] Freimuth, Blügel, Mokrousov, arXiv: 1305:4873v1 (2013); [4] Lowitzer, Ködderitzsch, Ebert, PRL **105**, 266604 (2010); [5] Ebert, Mankovsky, Ködderitzsch, PRL **107**, 066603 (2011)

MA 44.2 Thu 15:15 HSZ 403

Linear and nonlinear stationary ac response of the magnetization of nanomagnets in the presence of thermal agitation and spin-transfer torques — D.J. Byrne[1], •W.T. Coffey[2], Y.P. Kalmykov[3], and S.V. Titov[4] — [1]School of Physics, University College Dublin, Belfield, Dublin 4, Ireland — [2]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [3]Université de Perpignan Via Domitia, Laboratoire de Mathématiques et Physique, F-66860, Perpignan, France — [4]Kotelnikov Institute of Radio Engineering and Electronics of the RAS, Russia

Thermal fluctuations of nanomagnets driven by spin-polarized currents are treated via the Landau-Lifshitz-Gilbert equation generalized to include both the random thermal noise field and the Slonczewski spin-transfer torque term. The statistical moment method [Y. P. Kalmykov et al., Spin-torque effects in thermally assisted magnetization reversal: Method of statistical moments, Phys. Rev. B 88 (2013) 144406] for the study of out-of-equilibrium time independent observables of the generic nanopillar model of a spin-torque transfer (STT) device subjected to thermal fluctuations is extended to the stationary time dependent observables arising from applied a.c. field. The virtue of our solutions is that they hold for the most comprehensive formulation of the generic nanopillar model, i.e., for arbitrary directions of the external field and spin polarization and for arbitrary free energy density, yielding the STT switching characteristics under conditions otherwise inaccessible. Both the dynamic magnetic susceptibility and dynamic hysteresis are determined for an a.c. field of arbitrary strength.

MA 44.3 Thu 15:30 HSZ 403

Magnons in ultrathin ferromagnetic films with a large perpendicular magnetic anisotropy — •Huajun Qin[1], Khalil Zakeri Lori[1], Arthur Ernst[1], Tzu-Hung Chuang[1], Ying-Jiun Chen[1], Yang Meng[1], and Jürgen Kirschner[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany

Ultrathin films with a large perpendicular magnetic anisotropy are of great fundamental as well as technological interest. We present the first experimental observation of high energy magnon excitations in a set of tetragonally distorted ultrathin FeCo films with a large perpendicular magnetic anisotropy. We use spin polarized electron energy loss spectroscopy to excite and probe the magnetic excitations. In this experiment, the polarization vector of the incoming beam is perpendicular to the film magnetization. The magnon dispersion relation and lifetime are probed along the $\bar{\Gamma}$–$\bar{X}$ direction of the surface Brillouin zone. The magnons possess energies up to 160 meV and lifetimes in the range of a few tens of femtoseconds down to sixteen femtoseconds at the zone boundary. Combined with the first-principles calculations, we show that in addition to the tetragonal distortion, which is the origin of the large perpendicular magnetic anisotropy, the interfacial electronic hybridization also has an impact on the properties of magnons [1].

[1] H.J. Qin, Kh. Zakeri, A. Ernst, T.-H. Chuang, Y.-J. Chen, Y. Meng, and J. Kirschner, PRB **88**, 020404 (R) (2013).

MA 44.4 Thu 15:45 HSZ 403

Magnetic excitations in ultrathin Co films on Ir(100) — •Ying-Jiun Chen[1], Khalil Zakeri[1], Arthur Ernst[1,3], Huajun Qin[1], Tzu-Hung Chuang[1], Yang Meng[1], and Jürgen Kirschner[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität

Halle-Wittenberg, 06120 Halle, Germany — [3]Wilhelm Ostwald Institut für Physikalische und Theoretische Chemie, Universität Leipzig, Linnéstrasse 2, 04103 Leipzig, Germany

We report on the experimental results of high-energy magnetic excitations in an ultrathin face-centered tetragonal (fct) Co film with a thickness of 2.8 monolayer (ML) grown on the (5×1) reconstructed Ir(100) surface. The magnon dispersion relation is measured along the main symmetry axes of the sureface Brillouin zone *i.e.* $\bar{\Gamma}$-$\bar{X}$ and $\bar{\Gamma}$-$\bar{M}$ directions. The excitation energy increases as the wave-vector increases and reaches a value of about 260 meV at the $\bar{X}$-point and 310 meV at the $\bar{M}$-point. By comparing the results to the ones of a 3 ML Co film grown on Cu(100), and also to the results of theoretical calculations, we discuss how the lattice strain and Co_{3d}-Ir_{5d} hybridizations of the electronic states influence the magnon dispersion relation.

MA 44.5 Thu 16:00 HSZ 403

Spin Excitations in Individual Fe4 Molecular Magnets — •Jacob Burgess[1,2], Luigi Malavolti[3], Valeria Lanzilotto[3], Matteo Mannini[3], Shichao Yan[1,2], Deung-Jang Choi[1,2], Steffen Rolf-Pissarczyk[1,2], Andrea Cornia[4], Roberta Sessoli[3], and Sebastian Loth[1,2] — [1]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg — [2]Max Planck Institute for Solid State Research, Stuttgart — [3]Department of Chemistry, University of Florence & INSTM, Italy — [4]Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia & INSTM, Italy

Single molecule magnets (SMMs) are in general large and fragile molecules. This constitutes a significant challenge in incorporating them into spintronics applications, and also to the investigation of the molecules via scanning tunneling microscopy (STM). The Fe4 molecule [1] stands out as an unusually robust SMM that can withstand thermal evaporation as well as a wide range of possible functionalizations.

Here we present the first STM investigations of individual Fe4 molecules thermally evaporated onto a single layer Cu2N on a Cu (100) crystal. Magnetic excitations at meV energies can be detected by inelastic electron tunneling spectroscopy. Comparison to the excitation spectrum computed from a Spin Hamiltonian accounting for all spins individually allows extraction of anisotropy and exchange parameters for isolated molecules. This experiment indicates the surface has a minimal effect on the magnetic anisotropy of Fe4 molecules.

[1] M. Mannini et al., Nature 468, 417 (2010).

MA 44.6 Thu 16:15 HSZ 403

Novel spin excitations in the quasi-1D Haldane chain $SrNi_2V_2O_8$ under magnetic field — •Anup K. Bera[1], Bella Lake[1], Nazmul Islam[1], Bastian Klemke[1], Joseph M. Law[2], Astrid Schneidewind[3], Jitae Park[3], and Elisa Wheeler[4] — [1]Helmholtz-Zentrum Berlin, Berlin, Germany — [2]Helmholtz-Zentrum Dresden Rossendorf, Dresden, Germany — [3]Forschungs-Neutronenquelle Heinz Maier-Leibnitz, Garching, Germany — [4]Institut Laue-Langevin, Grenoble, France

Spin-1 Heisenberg antiferromagnetic chains (Haldane chains) demonstrate novel behaviors where quantum fluctuations destroy long-range order (LRO) even at T = 0. They have spin singlet ground state and gapped magnon (S=1) excitations. Applied magnetic fields suppress zero-point fluctuations, and restore a gapless spectrum. The result is a quantum phase transition at a critical field H_c, to a magnetized state. The presence of anisotropy and interchain interactions lead to more complex behavior and a richer phase diagram.

Spin excitations have been investigated experimentally on the model compound $SrNi_2V_2O_8$ having substantial interchain interactions and single-ion anisotropy. Field-induced 3D magnetic ordering has been found with two critical fields (12 T for $H \perp c$ and 20.8 T $H \parallel c$ at 4.2 K, respectively). For $H \perp c$, neutron scattering reveal (i) a unique field dependence of the gapped triplet excitations at $H < H_c$, (ii) gapless excitations at H_c, and (iii) the reappearance of gapped excitations at $H > H_c$. The dispersion at $H = H_c$ is gapless and linear, in contrast to the gapped and quadratic dispersions at both $H > H_c$ and $H < H_c$.

MA 45: Spin Structures at Surfaces and in thin films I (Skyrmions)

Time: Thursday 15:00–18:30 Location: BEY 118

MA 45.1 Thu 15:00 BEY 118

fcc-Fe monolayer on Ir(111): Atomic-scale meron-antimeron spin-texture predicted from a multi-scale study based on an realistic *ab initio* spin model — •David Siegfried Georg Bauer, Nicolai Kiselev, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

This research is work in progress and we hope to present here the final answer of the magnetic structure for the Fe/Ir(111) system. We are using a multi-scale approach, employing a classical spin Hamiltonian containing Heisenberg (EX), four-spin (FS), and Dzyaloshinskii-Moriya (DM) interaction as well as magnetic anisotropy with newly fitted exchange parameters obtained from *ab initio* calculations of Ref. [1].
We found a new class of magnetic patterns consisting of staggered meron-antimeron pairs within a supercell of 128 atoms, containing 9 meron-antimeron pairs and 18 topological defects. We carefully checked the shape and size of the supercell, which is commensurate with the underlying magnetic lattice. The magnetic structure is in very good agreement to the experimental SP-STM data [1]. We explain this structure by an interplay between the EX, FS and DM interaction, where the FS interaction plays a key role making this structure energetically favorable in comparison to a skyrmion lattice. Due to the local topological charges of the (anti-)meron of $Q = (-)1/2$, the electron may pick up a Berry phase when transversing through such a magnetic structure giving rise to interesting transport properties.
[1] S. Heinze *et al.*, Nature Phys. **7**, 713 (2011).

MA 45.2 Thu 15:15 BEY 118

Tailoring magnetic skyrmions in ultra-thin transition-metal films — •Bertrand Dupé, Markus Hoffmann, Charles Paillard, and Stefan Heinze — Institue of Theoretical Physics and Astrophysics, University of Kiel, 24098 Kiel, Germany

Skyrmions in magnetic materials offer attractive perspectives for future spintronic applications [1] since they are topologically stabilized spin structures on the nanometer scale which can be manipulated at low electric current densities [2,3]. Recently, it has been discovered that due to the broken inversion symmetry at surfaces magnetic skyrmion lattices can occur in ultra-thin transition metal films [4,5]. Here, we present an understanding of skyrmions in such systems based on first-principles electronic structure theory. We determine the magnetic interactions for ultra-thin films composed of Pd and Fe on the Ir(111) surface using density functional theory and explain the occurrence of skyrmion phases in an external magnetic field using Monte-Carlo simulations. Our simulations not only confirm the succession of phases recently reported in experiments [5] but also demonstrate the possibility of tailoring skyrmion properties at transition-metal interfaces [6].

[1] J. Sampaio, *et al* Nature Nanotech. **8**, 839 (2013). [2] F. Jonietz, *et al* Science **330**, 1648 (2010). [3] X. Z. Yu, N. Kanazawa, *et al* Nature Comm. **3**, 988 (2012). [4] S. Heinze, *et al* Nature Phys. **7**, 713 (2011). [5] N. Romming, *et al* Science **341**, 636 (2013). [6] B. Dupé, *et al* submitted.

MA 45.3 Thu 15:30 BEY 118

Temperature-driven phase transition of Fe/Ir(111) nanoskyrmions — •Stefan Krause, Andreas Sonntag, Jan Hermenau, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg

Skyrmions are topologically protected field configurations with particle-like properties. They are in the focus of many ongoing investigations due to their potential application for future spintronic devices. Using spin-polarized scanning tunneling microscopy (SP-STM) at low temperature ($T = 11$ K), a lattice of nanoskyrmions has been shown to be the ground state of the one-atomic-layer thick Fe/Ir(111) surface [1].

In our recent SP-STM studies we investigated the influence of temperature onto the Fe/Ir(111) nanoskyrmionic lattice. The experiments reveal that the lattice is stable against thermal agitation up to $T \approx 27.4$ K. Further elevating T to 28.0 K results in a fading of the magnetic SP-STM contrast, indicating a phase transition into the paramagnetic state. By repeatedly varying T we elaborate a very sharp phase transition at $T \approx 27.7$ K. At second monolayer Fe step edges the skyrmionic lattice is found to persist even to higher T, which is attributed to pinning.

The experimental results will be presented and discussed in terms of magnetic corrugation amplitude of the skyrmion lattice and pinning decay length.

[1] S. Heinze *et al.*, Nat. Phys. **7**, 713 (2011).

MA 45.4 Thu 15:45 BEY 118

Exotic topologically nontrivial spin structures in systems with competing Dzyaloshinskii-Moriya interaction and four-spin interaction — •Nikolai S. Kiselev, David S. G. Bauer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Systems of low dimensionality such as monatomic chains, nano-islands and monolayers exhibit unique properties different from bulk materials. In particular, due to the surface/interface induced changes of the electronic properties, monolayers of transition metals show unusual magnetic properties. For instance, the ground state of the Fe/Ir(111) [1] system corresponds to a complex previously unknown spin structure, which we identified as a staggered lattice of chiral meron-animeron pairs. The spin structure in such systems arises due to the interplay of three main energy contributions: Heisenberg exchange, Dzyaloshinskii-Moriya interaction, and four-spin interaction (FSI). We present a three-dimensional magnetic phase diagram (PD) in terms of the applied magnetic field, four-spin interaction coupling constant, and temperature. In this PD we identified the area of existence of the spiral state and the hexagonal lattice of nano skyrmions, which can be stabilized at zero field. We explain mechanism of their stabilization. Generalization of our model explains the emergence of the spiral state and skyrmions in Pd/Fe/Ir(111) [2].

[1] S. Heinze et al., Nature Phys. 7, 713 (2011).
[2] N. Romming et al., Science 341, 636 (2013).

MA 45.5 Thu 16:00 BEY 118

Non-collinear spin structure in an Fe monolayer on Ir(001) — •Markus Hoffmann, Bertrand Dupé, Paolo Ferriani, and Stefan Heinze — Institut für Theoretische Physik und Astrophysik, Universität Kiel, 24098 Kiel

Recently, complex magnetic ground states have been reported for a number of transition-metal nanostructures on surfaces [1-4]. The driving force behind these non-collinear spin structures is a competition of exchange, Dzyaloshinskii-Moriya (DM) and higher-order spin interactions. Here, we present a first-principles study of the magnetic properties of an Fe monolayer on Ir(001) based on density-functional theory using the projector augmented wave method as implemented in the VASP code. After mapping our total energy calculations to an extended Heisenberg model we perform Monte-Carlo simulations. We find that a complex non-collinear spin structure can be stabilized by higher-order exchange interactions. Its low total energy is confirmed by subsequent DFT calculations. Finally, we present simulated spin-polarized scanning tunneling microscopy images which allow to verify the proposed spin structure experimentally.

[1] P. Ferriani *et al.*, Physical Review Letters **101**, 027201 (2008).
[2] Y. Yoshida *et al.*, Physical Review B **85**, 155406 (2012).
[3] M. Menzel *et al.*, Physical Review Letters **108**, 197204 (2012).
[4] S. Heinze *et al.*, Nature Physics **7**, 713 (2011).

MA 45.6 Thu 16:15 BEY 118

In situ conversion electron Mössbauer spectroscopy on ultrathin Fe(100)/Ir(100) films — •Sergey Makarov[1,2], Werner Keune[1,2], Heiko Wende[1], and Jürgen Kirschner[2] — [1]Fakultät für Physik und CeNIDE, Universität Duisburg-Essen — [2]Max-Planck-Institut für Mikrostrukturphysik Halle

In the present work we apply ^{57}Fe conversion electron Mössbauer spectroscopy for the study of magnetic order in uncoated three- and four-atomic monolayers (ML) thick epitaxial ^{57}Fe(100) ultrathin films grown in ultrahigh vacuum by molecular - beam epitaxy on the Ir(100) surface with the (5x1)Hex reconstruction. The spectra were taken in situ in UHV in zero external magnetic field at 30 K using a channeltron electron detector.

These spectra of 3 and 4 ML ^{57}Fe on Ir(100)-(5x1)Hex reveal magnetic order even at 30 K. Surprisingly, the measured CEM spectra indicate two inequivalent ^{57}Fe sites. Moreover, for 3 ML ^{57}Fe we obtain the average angle between the hyperfine field direction and γ-radiation, which shows a strong out-of-plane component of Fe spin orientation. In contrast, a preferred in-plane Fe spin alignment for 4 ML ^{57}Fe/Ir(100)-(5x1)Hex was observed.

15 min. break

MA 45.7 Thu 16:45 BEY 118

The influence of oxygen adsorption on the magnetic structure of the iron monolayer on the Ir(001) surface — •Frantisek Maca[1], Josef Kudrnovsky[1], Vaclav Drchal[1], and Josef Redinger[2] — [1]Institute of Physics ASCR, Prague, Czech Republic — [2]Institute of General Physics TU Vienna, Vienna, Austria

We present an ab initio study of the electronic structure and magnetic order of one Fe monolayer on the Ir(001) surface covered by adsorbed oxygen and hydrogen. We show that the adsorption of oxygen (and also of the hydrogen) leads to the p(2x1) antiferromagnetic order. The p(2x1)-ordering is weakened by decreasing oxygen coverage and changes into complex magnetic ground state for the oxygen free case. This result was obtained by two complementary approaches, namely using the total energy evaluations for limited number of magnetic configurations and by a disordered local moment analysis. Based on the calculated magnetic ground states, we also estimate theoretically the spin-polarized scanning tunneling images using a simple Tersoff-Hamann model.

F. Máca, J. Kudrnovský, V. Drchal, and J. Redinger, Phys. Rev. B 88, 045423 (2013).

MA 45.8 Thu 17:00 BEY 118

New mechanism for Skyrmion phase stabilization in multilayers of transition metals — •Ashis Kumar Nandy, Nikolai Kiselev, David Bauer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany

Previously, Skyrmions have been experimentally found in bulk B20 materials such as MnSi[1], or layers of FeCoSi [2]. Recently, Skyrmions which are observed in an atomic scale multilayer of transition metals as in Pd/Fe/Ir(111)[3] exist at an applied magnetic field of ~ 1 T. The skyrmion size is about ~ 1 - 10 nm. Here we present a multi-scale model based on ab initio calculations and atomistic spin dynamic simulation which predict the existence of a skyrmionic phase in transition metal monolayers e.g. Mn/W(110) or Fe/Ir(111) at high magnetic field. Theoretically predicted Skyrmions have a much higher stability range in an applied magnetic field and much smaller sizes of about 1 nm. We provide a description for the complex phases occurring in such systems and present a magnetic phase diagram for some real compounds. The stability of found solutions are discussed in details.

We propose a new mechanism based on an interplay between internal and surface/interface induced interactions in transition metal multilayers, which can allow one to stabilize a lattice of skyrmions and isolated skyrmions even at zero magnetic field by adjusting only thicknesses and number of layers in multilayers. [1] S. Mühlbauer *et al.*, Science **323**, 915 (2009). [2] X. Z. Yu *et al.*, Nature **465**, 901 (2010). [3] N. Romming *et al.*, Science **341**, 636 (2013).

MA 45.9 Thu 17:15 BEY 118

MnGe grown as a thin film - a new aspirant in skyrmion research — •Josefin Engelke[1], Dirk Menzel[1], and Vadim Dyadkin[2] — [1]IPKM, TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig, Germany — [2]Swiss-Norwegian Beamlines at the ESRF, Grenoble, 38000, France

Since the discovery of skyrmions in MnSi, there has been a lot of research in the field of the magnetic B20 alloys. Especially the growth of thin films is of great interest, because the skyrmion phase is enlarged compared to bulk material [1,2]. While most of the compounds exhibit a very low ordering temperature, MnGe offers magnetic order at much higher temperatures, which brings it closer to application in future spintronic devices.

We have grown MnGe as a thin film on Si(111) substrates by MBE [3]. The films have been structually characterized by RHEED, AFM and XRD. These techniques give evidence that MnGe forms in the cubic B20 crystal structure as islands exhibiting a very smooth surface. A magnetic characterization reveals that the ordering temperature of MnGe thin films is slightly enhanced compared to bulk material. The properties of the helical magnetic structure obtained from magnetization and magnetoresistivity measurements are compared with films of the related compound MnSi. The much larger Dzyaloshinskii-Moriya interaction in MnGe results in a higher rigidness of the spin helix.

References: [1] J. Engelke et al., J. Phys. Soc. Japn. 81, 124709

(2012). [2] M. N. Wilson et al., Phys. Rev. B 86, 144420 (2012). [3] J. Engelke et al., J. Phys.: Condens. Matter 25, 472201 (2013).

MA 45.10 Thu 17:30 BEY 118

Creation and annihilation of skyrmions in ultrathin magnetic films — •Julian Hagemeister, Robert Wieser, Elena Vedmedenko, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg

Recently, the possibility of a selective manipulation of skyrmion structures has been demonstrated experimentally [1]. While the feasibility of the skyrmion-manipulation has been discussed for several systems [2], the time scale of the switching behavior of skyrmions and the energy barrier of this process is unknown up to now.

Here, we present a theoretical description of the thermal and field dependent stability of skyrmions obtained from classical Monte-Carlo simulations within the Heisenberg model for the example of a Pd monolayer on Fe/Ir(111) [1]. The skyrmions are stabilized by a ferromagnetic exchange coupling, the Dzyaloshinskii-Moriya-interaction and the Zeeman energy. The switching mechanism between the ferromagnetic and the skyrmionic state via an activated transition of the energy barrier between these two phases is studied. The field dependence of the life-times is discussed. Furthermore, the forced creation of a skyrmion within a ferromagnetic phase by a targeted spin manipulation is investigated.

[1] N. Romming, C. Hanneken, M. Menzel, J. E. Bickel, B. Wolter, K. von Bergmann, A. Kubetzka, and Roland Wiesendanger, (2013). Science 341, 636-639. [2] S.-Z. Lin, C. Reichhardt, and A. Saxena, (2013). Appl. Phys. Lett. 102, 222405.

MA 45.11 Thu 17:45 BEY 118

Skyrmion magnetic structure of an ordered FePt monolayer deposited on Pt(111) — •Svitlana Polesya, Sergiy Mankovsky, Sven Bornemann, Jan Minar, and Hubert Ebert — Dept. Chemie/Physikalische Chemie, Universität München, Butenandtstr. 5-13, D-81377 München, Deutschland

The effect of the Dzyaloshinsky-Moriya interaction on the magnetic structure of an ordered FePt monolayer deposited on Pt (111) surface has been investigated[1]. All exchange interactions are obtained by means of first-principles calculations, using the spin-polarized relativistic Korringa-Kohn-Rostoker multiple scattering formalism. The interplay of relativistic exchange coupling interactions leads to a helimagnetic (HM) structure at normal conditions for $T = 0$ K. An applied magnetic field, however, creates a so-called Skyrmion structure, which is formed into a Skyrmion lattice at a certain value of the magnetic field. A T-B phase diagram for FePt/Pt(111) has been obtained performing Monte Carlo simulations based on the extended Heisenberg model.

[1] S. Polesya, S. Mankovsky, S. Bornemann, J. Minár, H. Ebert, arXiv:1310.5681

MA 45.12 Thu 18:00 BEY 118

Skyrmion states in triangular-lattice Heisenberg antiferromagnet with frustrated interactions — •Andrey Leonov and Maxim Mostovoy — Zernike Institute for Advanced Materials, University of Groningen, Groningen, 9700AB, The Netherlands

In geometrically frustrated magnets with the triangular lattice, the interplay between nearest- and next-nearest neighbor interactions can stabilize a variety of interesting multi-q phases including the skyrmion crystal state. The spin structure of these skyrmions is somewhat different from that of skyrmions induced in magnets with a non-centrosymmetric lattice by the Dzyaloshinskii-Moriya (DM) interaction, which has lead to difference in static and dynamic properties of these two types of skyrmions. In particular, the DM skyrmions repel each other, whereas the skyrmions on the triangular lattice show the long-ranged attraction that leads to the formation of metastable skyrmion clusters and may stabilize the skyrmion liquid state. In addition, the skyrmions in frustrated systems have more low-energy degrees of freedom and can carry the topological charge and chirality of either sign for a fixed external magnetic field. We applied Monte Carlo simulations to study the rich magnetic field phase diagram of a frustrated triangular antiferromagnet with a uniaxial anisotropy. Using the Landau-Lifshitz-Gilbert equation, we also studied dynamical properties of isolated skyrmions, skyrmion pairs and skyrmion crystals, such as the excitation of collective modes of these systems with time-dependent external magnetic fields and currents.

MA 45.13 Thu 18:15 BEY 118

The role of cubic and exchange anisotropies in the thermodynamical stability of skyrmions and half-skyrmions in cubic helimagnets — •Andrey Leonov[1] and Ulrich K. Rössler[2] — [1]Zernike Institute for Advanced Materials, University of Groningen, The Netherlands — [2]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

In non-centrosymmetric chiral magnets, *isotropic* Dzyaloshinskii-Moriya interactions induce long-range 1-dimensional (cones and helicoids) and 2-dimensional ($\pm\pi$-skyrmions and $\pi/2$-skyrmions) homochiral modulations of the magnetization [1]. In this contribution we investigate the role of small anisotropic forces as cubic anisotropy and anisotropic exchange in suppression of the conical phase and the thermodynamical stability of skyrmions [2]. We also consider reorientational effect of cubic anisotropy on the propagation direction of helicoids and axes of skyrmions along certain crystal directions. The constructed T-H phase diagrams hold existence regions for different modulated and homogeneous phases separated by first- and second-order transition lines. The results demonstrate that a plethora of different precursor phenomena, modulated mesophases, and reorientation transitions may arise in cubic helimagnets near magnetic ordering depending on very weak magnetic couplings. [1] U. K. Rößler et al., J. of Phys.: Conf. Ser. 303, 012105 (2011); [2] A. Leonov, Ph.D thesis, Dresden University of Technology, Dresden (2012).

MA 46: Graphene: Spintronics, transistors, and sensors (with DY/DS/HL/O/TT)

Time: Thursday 15:00–18:00 Location: POT 081

MA 46.1 Thu 15:00 POT 081

Graphene's RF Potential: How harmful is the Zero Bandgap? — Kyle D. Holland[1], Navid Paydavosi[1], Neophytos Neophytou[2], •Diego Kienle[3], and Mani Vaidyanathan[1] — [1]Department of Electical and Computer Engineering, University of Alberta — [2]Institute for Microelectronics, Technical University of Vienna — [3]Institute of Theoretical Physics I, University of Bayreuth

With the aid of self-consistent quantum-mechanical simulations and simple expressions for the radio-frequency (RF) metrics, we examine the impact of a lack of a bandgap on limiting the RF potential of graphene transistors. Considering various RF figures of merit, we show that the lack of a bandgap leads to all RF metrics being optimal when the bias point is chosen such that the drain Fermi level aligns with the Dirac point at the midpoint of the channel. We further quantify the precise extent to which the lack of a bandgap limits the transistor's cutoff frequencies, an issue that has been flagged as requiring crucial attention to make graphene transistors competitive. For an 18-nm channel length, we show that the extrinsic unity-current-gain frequency could be improved by 300 GHz and the unity-power-gain frequency could be doubled if a bandgap could be introduced to reduce the output conductance to zero. [1] K. D. Holland, N. Paydavosi, N. Neophytou, D. Kienle, and M. Vaidyanathan, IEEE Trans. Nanotechnol. 12, 566 (2013).

MA 46.2 Thu 15:15 POT 081

Atomic layer deposited aluminum oxide on epitaxial graphene without surface activation — •Peter Wehrfritz[1], Florian Speck[2], Felix Fromm[1], Stefan Malzer[3], and Thomas Seyller[1] — [1]TU Chemnitz, Institut für Physik, Chemnitz, Deutschland — [2]FAU Erlangen-Nürnberg, Department Physik, Erlangen, Deutschland — [3]FAU Erlangen-Nürnberg, Angewandte Physik, Erlangen, Deutschland

Graphene with its high charge carrier mobility is a promising material for analog RF field effect transistors. The preparation of the required insulating layer is still challenging. Atomic layer deposition (ALD) has been extensively studied in the context of alternative dielectrics for silicon-based field effect transistors owing to its capabilities to produce high-quality, homogeneous oxide layers. However, nucleation of

ALD growth is strongly suppressed on inert graphene surfaces.

In this contribution we present an approach to obtain conformal aluminum oxide (Al_2O_3) on epitaxial monolayer graphene on silicon carbide (SiC). We demonstrate that closed layers of Al_2O_3 can be deposited on the so called buffer layer. This buffer layer covered by ALD-Al_2O_3 can then be decoupled from the SiC substrate by means of hydrogen intercalation yielding quasi-freestanding monolayer graphene with an insulating dielectric on top. We investigated the quality of the graphene layer and ALD-Al_2O_3 using X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, AFM, and Hall effect measurements.

MA 46.3 Thu 15:30 POT 081

Spin-dependent negative differential resistance in composite graphene superlattices — •Christopher Gaul[1,2], Javier Munárriz[2], Andrey V Malyshev[2], Pedro A Orellana[3], Cord A Müller[4], and Francisco Domínguez-Adame[2] — [1]Max-Planck-Institut für Physik Komplexer Systeme, Dresden — [2]Universidad Complutense de Madrid, Spain — [3]Universidad Técnica Federico Santa María, Casilla 110 V, Valparaíso, Chile — [4]Fachbereich Physik, Universität Konstanz

We propose and study a compound system of a graphene nanoribbon and a set of ferromagnetic insulator strips deposited on top of it. The periodic array of ferromagnetic strips induces a proximity exchange splitting of the electronic states in graphene, resulting in the appearance of a superlattice with a spin-dependent energy spectrum. We find clear signatures of spin-dependent negative differential resistance. The electric current through the device can be highly polarized and both the current and its polarization manifest non-monotonic dependence on the bias voltage. The device operates therefore as an Esaki spin diode, which opens possibilities to design new spintronic circuits.

Phys. Rev. B 88, 155423 (2013)

MA 46.4 Thu 15:45 POT 081

Exchange coupling between localized defect states in graphene nanoflakes — •Matthias Droth and Guido Burkard — University of Konstanz, Germany

Graphene nanoflakes are interesting because electrons are naturally confined in these quasi zero-dimensional structures, thus eluding the need for a bandgap. Defects inside the graphene lattice lead to localized states and the spins of two such localized states may be used for spintronics. We perform a tight-binding description on the entire system and, by virtue of a Schrieffer-Wolff-transformation on the bonding and antibonding states, we extract the coupling strength between the localized states. The coupling strength allows us to estimate the exchange coupling, which governs the dynamics of singlet-triplet spintronics.

MA 46.5 Thu 16:00 POT 081

Novel fabrication method of lateral spin valve devices based on graphene on hexagonal boron nitride — Marc Drögeler[1], Frank Volmer[1], •Maik Wolter[1], Bernat Terrés[1], Kenji Watanabe[3], Takashi Taniguchi[3], Gernot Güntherodt[1], Christoph Stampfer[1,2], and Bernd Beschoten[1] — [1]2nd Institute of Physics and JARA-FIT, RWTH Aachen University, 52074 Aachen, Germany, EU — [2]Peter Grünberg Institute (PGI-8/9), Forschungszentrum Jülich, 52425 Jülich, Germany, EU — [3]National Institute for Materials Science, 1-1 Namiki, Tsukuba, 305-0044, Japan

Despite tremendous efforts in improving graphene-based spin transport devices the measured spin lifetimes are still orders of magnitude less than theoretically predicted. Contact-induced spin dephasing has recently been identified as the bottleneck for spin transport through Co/MgO spin injection and detection electrodes. It can, however, significantly be suppressed for devices with large contact resistance area products [1]. Simultaneously, a strong reduction of the charge carrier mobility is usually observed. We present a new method to fabricate graphene-based non-local spin valves on hexagonal boron nitride yielding spin lifetimes above 3 ns, spin diffusion length above 10 μm and large charge carrier mobilities above 30.000 cm^2/Vs.

[1] F. Volmer *et al.*, Phys. Rev. B **88**, 161405(R) (2013).

This work has been supported by DFG through FOR 912 and by EU through Graphene Flagship.

MA 46.6 Thu 16:15 POT 081

Suppression of contact-induced spin dephasing in graphene/Co/MgO_x spin-valve devices by successive oxygen treatments — Frank Volmer, •Christopher Franzen, Marc Drögeler, Eva Maynicke, Nils von den Driesch, Maren Laura Boschen, Gernot Güntherodt, and Bernd Beschoten — 2nd Institute of Physics and JARA-FIT, RWTH Aachen University, 52074 Aachen, Germany

By successive oxygen treatments of graphene non-local spin-valve devices we achieve a gradual increase of the contact resistance area products R_cA of the Co/MgO_x spin injection and detection electrodes and a transition from linear to non-linear characteristics in the corresponding dV/dI-curves. With this manipulation of the contacts both spin lifetime and amplitude of the spin signal can significantly be increased by a factor of seven in the same device. This demonstrates that contact-induced spin dephasing is the bottleneck for spin transport in graphene devices with small R_cA values [1]. With increasing R_cA we furthermore observe the appearance of a second charge neutrality point (CNP) in gate dependent resistance measurements. Simultaneously we observe a decrease of the gate voltage separation between the two CNPs. The strong enhancement of the spin transport properties as well as the charge transport will be explained by the same gradual suppression of a Co/graphene interaction by improving the oxide barrier.

Work was supported by DFG/FOR 912 and EU/Graphene Flagship.

[1] F. Volmer *et al.* Phys. Rev. B **88**, 161405 (2013).

Coffee break (15 min.)

MA 46.7 Thu 16:45 POT 081

Development of an amperometric H2O2 sensor based on graphene — •Masoumeh Sisakhti[1], Alexander Zöpfl[2], Jonathan Eroms[1], Thomas Hirsch[2], and Christoph Strunk[1] — [1]Institut für Experimentelle und Angewandte Physik,Universität Regensburg — [2]Institut für analytische Chemie,Universität Regensburg

The precise detection of Hydrogen peroxide (H2O2) has been a widely researched topic and the focus of a vast amount of attention, owing to its vital role in biological systems, as well as its utility in food, pharmaceutical and biochemical industries.

The objective of this work is to investigate a novel nonenzymatic, amperometric sensor for reliable determination of H2O2 based on graphene.

We produced graphene sensors based on three types of graphene: exfoliated graphene, CVD grown graphene and reduced graphene oxide and carried out cyclic voltammetry and amperometric experiments using a CH Instrument electrochemical analyzer. We demonstrate that all three graphene materials show excellent sensitivity to the catalytic reduction of H2O2 and are able to detect H2O2 concentrations down to 0.1 mM. rGO as well as graphene prepared by CVD are promising candidates for sensor applications since they are able to detect hydrogen peroxide with high sensitivity at moderate electrode potentials. Both materials are superior in the signal-to-noise ratio compared to exfoliated graphene. A further conjugation of enzymes to the defects within the carbon nano material as well as the assembly of 2D-layered composite materials will be perspective to biosensor applications.

MA 46.8 Thu 17:00 POT 081

Controlled chemical modification of graphene for applications in biosensing — •Marco R. Bobinger, Max Seifert, Anna Cattani-Scholz, and Jose A. Garrido — Walter Schottky Institut, Technische Universität München, Germany

Given its exceptional chemical and mechanical stability as well as its unique electronic properties, graphene is an extremely promising platform for biosensors. In order to use graphene in the biological environment and to improve sensing specificity and device performance, chemical functionalization schemes are needed to allow stable grafting of organic and bioorganic molecules onto graphene. In particular for applications in bioelectronics, the influence of the chemical functionalization of graphene on the generation of defects, strain, and doping has to be balanced with the desired modulation of the electronic properties of the produced graphene-organic hybrid material. In this work the effect of the controlled chemical modification of large area CVD-grown graphene via ozone treatment is investigated. This process creates sp3-like defects, related to covalently bound surface groups, e.g. OH-. Such ozone-treated surfaces are characterized by Raman- and X-ray photoelectron spectroscopy in order to investigate the degree of surface modification and the chemical composition of the surface terminations. The generated anchor groups are further used as binding sites for the modification of graphene with organic molecules.

MA 46.9 Thu 17:15 POT 081

Functionalization of Graphene for Biolectronic Applications — •Alina Lyuleeva[1], Lucas Hess[1], Frank Deubel[2], and Jose Antonio Garrido[1] — [1]Walter Schottky Institut, TU München, 85748 Garching — [2]Wacker Chemie AG, 81379 München, Germany

With its fascinating structural, chemical and electronic properties, graphene outperforms many materials and is expected to pare the way for a vast range of applications such as transparent electrodes, energy storage devices, high-frequency electronics, or biosensors. The performance of the devices for these various applications can be enhanced with the help of surface functionalization, allowing a versatile modification of the properties of this material. Here, we report on the covalent and thus robust functionalization of CVD graphene with enzymes for the development of novel devices for bioelectronic applications. Graphene solution-gated field-effect transistors (SGFETs) are functionalized using a controlled grafting of polymethacrylate (PMA) brushes. We will show how this material platform can be used for further functionalization with the enzyme acetylcholinesterase (AChE). The enzymes' activity can be monitored with the modified-graphene transistor allowing both the measurement of the concentration of the neurotransmitter acetylcholine as well as the inhibition of the enzyme by neurotoxins such as nerve agents or pesticides. Our study demonstrates the potential of graphene-based functionalized transistors for biosensing and bioelectronic application.

MA 46.10 Thu 17:30 POT 081

Coupling of electrogenic cells to graphene devices — Michael Sejer Wismer, Felix Rolf, Damia Viana, •Martin Lottner, Lucas Hess, and Jose A. Garrido — Walter Schottky Institut - Technische Universität München, Am Coulombwall 4, 85748 Garching

In this contribution, we will demonstrate the electrical coupling between electrogenic cells and graphene-based solution-gated field effect transistors (SGFETs). To this end, HEK293 and HL1 cells were cultured on 8x8 arrays of graphene SGFETs with feature sizes of 10 mu x 20 mu. Graphene was grown by chemical vapour deposition (CVD) on copper foil and transferred to sapphire substrates, on which field effect transistors were fabricated using standard semiconductor technology. The devices show a typical maximum transconductance of >100 muS at 0.1 V drain-source voltage. This value is stable over months of storage. HEK293 cells were used to analyse the electrical coupling between cells and transistors. A model considering the distribution of ions within the cell transistor cleft and ion sensitivity of the graphene SGFETs fits the measured signals very well. Additionally, nano-transistors were defined by e-beam lithography, which allowed feature sizes down to 50 nm. With these nanoscale devices a signal-to-noise ratio of 2.5 could be obtained within single recordings of HL1 activity. Analysis of the measured ionic currents allowed to draw conclusions about local inhomogeneities of ion channel concentration within the membrane. Further, experiments for the stimulation of PC12 cells using arrays of graphene SGFET and graphene-based microelectrode arrays (MEAs) are under preparation.

MA 46.11 Thu 17:45 POT 081

Graphene solution-gated field effect transistors on flexible substrates — •Andrea Bonaccini Calia, Benno M. Blaschke, Lucas H. Hess, Max Seifert, and Jose A. Garrido — Walter Schottky Institut, Technische Universität München, Germany

Graphene based solution-gated field effect transistors (SGFETs) hold great promise for biosensors and bioelectronic applications. Due to its unique combination of electronic, mechanical, and chemical properties, such as high charge carrier mobility, flexibility and good biocompatibility, graphene has been shown to be an excellent material for sensing in electrolyte environments. Sensors based on graphene SGFETs have already been realized on rigid substrates for various analytes, as well as for the detection of cell signals. However, this technology hold some severe problems for biomedical and in vivo applications. One of the major problems is the rigidity of the substrate itself, which does not allow a proper mechanical matching to the biological tissue, resulting in the formation of scar tissue. Therefore, flexible devices are currently considered as a major step towards the development of more biocompatible implants. In this work, an array of graphene SGFETs is fabricated on a flexible polymer substrate. We present a detailed electrical characterization of the flexible graphene SGFETs in electrolyte and compare their performance to graphene SGFETs on rigid substrates. In addition, we analyze the effect of changes in the electrolyte's pH and ionic strength on the transistor performance and present a model to explain the obtained results. Furthermore, the low-frequency noise performance of graphene devices on flexible substrates is discussed.

MA 47: Spincaloric Transport I (jointly with TT)

Time: Thursday 16:45–18:45 Location: HSZ 403

MA 47.1 Thu 16:45 HSZ 403

Spin Hall magnetoresistance in ferromagnetic insulator/normal metal hybrids — •M. Althammer[1], S. Meyer[1], S. Geprägs[1], M. Opel[1], R. Gross[1,2], and S. T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, BAdW, Germany — [2]Physik-Department, Technische Universität München, Germany

Pure spin currents, i.e. the net flow of spin angular momentum without an accompanying charge current, represent a new paradigm for spin transport and spintronics. We have experimentally studied a new type of magnetoresistance effect, which arises from the interaction of charge and spin current flows in ferromagnetic insulator/normal metal hybrid structures. In more detail, we measured the resistance of yttrium iron garnet(YIG)/Pt, YIG/nonferromagnet/Pt, nickel ferrite/Pt, and magnetite/Pt hybrid structures as a function of the magnitude and the orientation of an external magnetic field. The resistance changes observed can be quantitatively traced back to the combined action of spin Hall and inverse spin Hall effect in the Pt metal layer, and are thus termed spin Hall magnetoresistance (SMR) [1, 2]. We show that the SMR is qualitatively different from the conventional anisotropic magnetoresistance effect arising in magnetic metals and is not due to a static proximity magnetization in Pt, as proposed by Huang et al. [3]. Financial support by the DFG via SPP 1538 (project no. GO 944/4) and the Nanoinitiative Munich (NIM) is gratefully acknowledged.

[1] Nakayama et al., PRL, **110**, 206601 (2013)
[2] Althammer et al., PRB, **87**, 224401 (2013)
[3] Huang et al., PRL, **109**, 107204 (2012)

MA 47.2 Thu 17:00 HSZ 403

Cooling nanodevices via spin-polarized currents — •Jochen Brüggemann[1], Stephan Weiss[2], Peter Nalbach[1], and Michael Thorwart[1] — [1]1. Institut für theoretische Physik, Universität Hamburg, Jungiusstrasse 9, 20355 Hamburg — [2]Theoretische Physik, Universität Duisburg-Essen & CENICE, 47048 Duisburg

We investigate a non-equilibrium cooling scheme for nanodevices utilizing spin-polarized currents inspired by the demagnetization cooling for macroscopic systems. A minimal model is employed including the following parts: First, a quantum dot coupled to ferromagnetic leads via electron tunneling, second, a localized magnetic moment on the dot interacting with the electron spins via exchange interaction and, finally, a single phonon mode coupled to both electric and spin degrees of freedom. By deriving and solving a quantum master equation for the reduced density matrix in the sequential tunneling limit, we are able to determine both spin and phonon dynamics. Due to the combination of spin-polarized currents and spin-phonon interaction we achieve an increase of the ground state population of the localized moment and thus, subsequently, of the phonon mode compared to its initial preparation.

MA 47.3 Thu 17:15 HSZ 403

Magneto-thermopower and Magnetoresistance of single Co-Ni alloy Nanowires — •Tim Böhnert[1], Victor Vega[2], Ann-Kathrin Michel[1], Victor M. Prida[2], and Kornelius Nielsch[1] — [1]Universität Hamburg, Hamburg, Germany — [2]Universidad de Oviedo, Oviedo, Spain

The magneto-thermopower is measured and correlated to the anisotropic magnetoresistance of Co-Ni alloyed nanowires with varying composition. The highest absolute and relative variation of the Seebeck coefficient in perpendicularly applied magnetic fields at room temperature are determined to be $1.5\,\mu VK^{-1}$ for $Co_{0.24}Ni_{0.76}$ and 8.1 % for $Co_{0.39}Ni_{0.61}$ nanowires. Power factors of $3.7\,mW/mK^2$ have been achieved, which is competitive with common thermoelectric materials like Bi_2Te_3. For Co-Ni nanowires containing up to 39 % Co a linear relationship between the magnetic field dependent change of the Seebeck coefficient and the electrical conductivity is found.

MA 47.4 Thu 17:30 HSZ 403

Magneto-thermopower on FeNi and FeCo thin films — •Sasmita Srichandan, Maximilian Schmid, Michael Vogel, Christoph Strunk, and Christian Back — Institute of Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany

We present measurements on the magneto-thermoelectric effects of 20 nm thick ferromagnetic films of permalloy (Py) [1] and FeCo alloy. The Py has been deposited on bulk MgO and GaAs substrates as well as on 100 nm thick SiN membranes. The dominant contribution to these effects turns out to be planar Nernst effect (PNE). For bulk substrate samples, the out of the plane temperature gradient gives rise to the anomalous Nernst effect (ANE). No ANE or transverse spin Seebeck effect (TSSE) signals are detected for the membrane samples. The observed TSSE for Py on bulk substrates is at least two orders of magnitude smaller than in earlier experiments [2].

In addition we study thermoelectric effects for FeCo alloy of various compositions deposited on the membrane. The advantage with FeCo is that the Fermi energy can be tuned throughout the band structure [3]. The domain walls in our samples are clearly visible in the TEM images. We present preliminary results of the effect of the domains on the thermoelectric effects.

[1] M. Schmid, S. Srichandan et.al PRL **111**,187201(2013).
[2] K. Uchida et.al Nature **455**,778(2008).
[3] K. Schwarz et.al J. Phys. F **14**,2659(1984).

MA 47.5 Thu 17:45 HSZ 403

Magneto-Thermopower and Giant Magnetoresistance measurements on single multilayered Co-Ni/Cu nanowires — •Anna Niemann[1], Tim Böhnert[1], Ann-Katrin Michel[1], Svenja Bässler[1], Johannes Gooth[1], Katalin Neurohr[2], Bence Tóth[2], László Péter[2], Imre Bakonyi[2], and Kornelius Nielsch[1] — [1]Institute of Applied Physics, Universität Hamburg, Hamburg, Germany — [2]Wigner Institute, Budapest, Hungary

The magneto-thermopower (MTP) is linked to the giant magnetoresistance (GMR) of individual multilayered Co-Ni/Cu nanowires with varying Cu thickness. Both magneto effects are studied temperature dependent in perpendicular magnetic fields leading to cross plane GMR effects of up to 15 % at RT. This is a typical effect size for electrodeposited nanowires. A linear dependence between thermopower S and conductivity σ of the nanowires–with the magnetic field as an implicit variable–is found at a wide temperature range (50 K to 325 K). This observation is in agreement with the Mott formula with an additional thermopower offset, which allows the estimation of the absolute Seebeck coefficient of the contact material.

The linear behavior–S vs. σ–and the Mott formula are used to calculate the energy derivative of the resistivity, which can be further correlated to the transmission function serving as a starting point in theoretical models. Magneto-thermal conductance measurements are planned to complete the characterization of the spin-caloritronic properties, in particular to validate the Wiedemann-Franz law in cross-plane GMR structures.

MA 47.6 Thu 18:00 HSZ 403

The anomalous Nernst effect in the triplet superconductor Sr_2RuO_4 — •Martin Gradhand[1], Karol I. Wysokinski[2], and James F. Annett[1] — [1]H . H. Wills Physics Laboratory, University of Bristol, Tyndall Ave, BS8-1TL, UK — [2]Institute of Physics, M. Curie-Skłodowska University, Radziszewskiego 10, PL-20-031 Lublin, Poland

The existence of the time reversal symmetry breaking in the superconducting state of Sr_2RuO_4 is crucial for the understanding of the pairing mechanism in this material. It is believed to show triplet p-wave pairing with a finite orbital and spin momentum. The measured optical Kerr effect [1] in its superconducting state caused enormous theoretical effort with different possible explanations. [2]

Another way to proof or disproof the existence of the time reversal symmetry breaking would be highly desirable. Here we present, two routes strongly related to each other. On one hand we address the existence and magnitude of the orbital magnetic moment relying on the Berry curvature expression for periodic crystals. On the other hand we will discuss the possibility of a superconducting current induced by temperature gradients - the anomalous Nernst effect.

[1] J. Xia, et al. Phys. Rev. Lett. **97**, 167002 (2006)
[2] V. M. Yakovenko Phys. Rev. Lett.**98** 087003 (2007), V. P. Mineev Phys. Rev. B **76** 212501 (2007), E. Taylor C. Kallin Phys. Rev. Lett. **108** 157001 (2012), M. Gradhand et al. Phys. Rev. B **88**, 094504 (2013)

MA 47.7 Thu 18:15 HSZ 403

Magnetic field dependence of the thermal conductivity of LCMO — •Christoph Euler, Paulina Holuj, Tino Jäger, Christian Mix, and Gerhard Jakob — University of Mainz, Germany

We measured the low-temperature out-of-plane thermal conductivity of LCMO using the differential 3-omega technique and found substantial magnetic field dependence between 100 K and room temperature. The effect is observed to be largest in the vicinity of the metal-insulator transition, since the enhancement in thermal conductivity is caused by the colossal magnetoresistance effect increasing the electronic contribution to the thermal conductivity. Our measurements allow a discussion of the Wiedemann-Franz law in the framework of strong electron-lattice coupling.

MA 47.8 Thu 18:30 HSZ 403

Magnon Hall effect and topology in kagomé lattices: A theoretical investigation — •Alexander Mook[1], Jürgen Henk[2], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle — [2]Institut für Physik, Martin-Luther-Universität, D-06120 Halle

Ferromagnetic insulators with Dzyaloshinskii-Moriya interaction show the magnon Hall effect, i. e., a transverse heat current upon application of a temperature gradient [1,2]. In our theoretical investigation we establish a close connection of the magnon Hall effect in two-dimensional kagomé lattices with the topology of their magnon dispersion relation. From the topological phase diagram we predict systems which show a change of sign in the heat current in dependence of the temperature. Furthermore, we derive a high-temperature limit of the thermal Hall conductivity; this quantity provides a figure of merit for the strength of the magnon Hall effect. Eventually, we compare the temperature dependence of the magnon Hall conductivity of the three-dimensional pyrochlore $Lu_2V_2O_7$ with experiment.

[1] Y. Onose et al., Science **329**, 297 (2010).
[2] R. Matsumoto, S. Murakami, Phys. Rev. B **84**, 184406 (2011).

MA 48: Poster: Spintronics (with TT)

Time: Thursday 17:00–20:00 Location: P1

MA 48.1 Thu 17:00 P1

Electrical detection of spin Hall effect in semiconductors — •Markus Ehlert[1], Cheng Song[1,2], Mariusz Ciorga[1], Thomas Hupfauer[1], Martin Utz[1], Dieter Schuh[1], Dominique Bougeard[1], and Dieter Weiss[1] — [1]Institute of Experimental and Applied Physics, University of Regensburg, Germany — [2]Key Laboratory of Advanced Materials, School of Material Science & Engineering, Tsinghua University, Beijing, China

We present different geometries which allow for the all-electrical detection of either direct spin Hall effect (DSHE) or inverse spin Hall effect (ISHE) in semiconductor microstructures. We describe our experimental methods and compare results to previous experiments and theory. In our DSHE experiments a spin-unpolarized charge current flows through a n-GaAs channel and induces, due to DSHE, a transverse spin current. Hence, spins accumulate at the boundaries of the channel and are detected by spin-sensitive Esaki diodes [1]. For ISHE experiments in p-GaAs we used spin-injecting contacts to generate a spin current, which, via ISHE, should lead to a measurable charge imbalance in a Hall bar geometry. Another ISHE device consists of the so-called H-bar geometry, where an electric current is driven in one leg of an H-shaped structure. This generates, due to DSHE, a transverse spin current, which flows along the connection between both legs of the "H". By means of ISHE a charge imbalance is then induced in the second leg of the "H" [2].

[1] M. Ehlert *et al.*, Phys. Rev. B **86**, 205204 (2012).
[2] M. Ehlert *et al.*, Phys. Status Solidi B (2013) (acc.).

MA 48.2 Thu 17:00 P1

Spin blockade effects in a GaMnAs double quantum dot system — Stefan Geissler[1], •Sebastian Pfaller[2], Andrea Donarini[2], Milena Grifoni[2], and Dieter Weiss[1] — [1]Institute for Exp. and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

Spin polarized transport measurements of a double quantum dot defined in a GaMnAs nano constriction are presented. In the experimental setup, the polarization of the leads as well as of the quantum dot system can be controlled by an external magnetic field. In presence of a magnetic field, differential conductance measurements show a gap opening in the charge stability diagrams, that can be explained by spin blockade effects. Transport calculations of metallic quantum double dots coupled to spin polarized leads show excellent agreement with experimental data.

MA 48.3 Thu 17:00 P1

Exciton dynamics in transition metal dichalcogenides — •Igor Libman, Hendrik Kuhn, Jan G. Lonnemann, Julia Wiegand, Michael Oestreich, and Jens Hübner — Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

Among the newly emerging two-dimensional transition metal dichalcogenides molybdenum disulfide (MoS_2) has attracted an increasing attention as promising material for transport, optical and spintronic applications [1]. A contrasting key feature to the ubiquitous mono- and bilayer graphene is the easily accessible direct optical band gap of single layer MoS_2 [2]. Furthermore, the two-component nature breaks the inversion symmetry [3] and leads jointly with spin-orbit interaction to a copious number of spin-optoelectronic effects. Here, we present a scheme for the investigation of the complex dynamics of A and B excitons and their excited states (A' and B') in single layer MoS_2 [4] by ultrafast two-color time-resolved laser spectroscopy with focus on distinct impact of the electron-phonon interaction [5] onto the spectral shape of the s- and p-equivalent excitons states.

[1] Q. H. Wang *et al.*, Nature Nanotech. **7**, 11 (2012).
[2] Andrea Splendiani *et al.*, Nano Lett., **10**, 1271 (2010).
[3] G. Sallen *et al.*, Phys. Rev. B, **86**, 081301(R) (2012).
[4] Diana Y. *et al.*, Phys. Rev. Lett, **111**, 216805 (2013).
[5] A. Marini, Phys. Rev. Lett. **101**, 106405 (2008).

MA 48.4 Thu 17:00 P1

Spin dynamics in quantum wells under surface acoustic waves — •Johannes Wanner[1], Cosimo Gorini[2], Peter Schwab[1], and Ulrich Eckern[1] — [1]Institute of Physics, University of Augsburg, 86135 Augsburg, Germany — [2]Service de Physique de l'Etat Condensé, CEA-Saclay, 91191 Gif sur Yvette, France

Various recent experiments have shown the flexibility of surface acoustic waves (SAW) as a mean for transporting charge and spin in quantum wells [1]. In particular, SAW have proven highly effective for the coherent transport of spin-polarized wave packets, suggesting their potential in spintronics applications. Motivated by these experimental observations we have theoretically studied the spin and charge dynamics in a quantum well under surface acoustic waves. Based on previous work by some of us [2], we show that the dynamics acquires a simple and transparent form in a reference frame co-moving with the SAW. The observed values for spin relaxation and precession length can thus be explained.

[1] H. Sanada et. al., Phys. Rev. Lett. **106**, 216602 (2011); O. Couto et. al., Phys. Rev. B **78**, 153305 (2008)
[2] P. Schwab et al., Phys. Rev. B **74**, 155316 (2006)

MA 48.5 Thu 17:00 P1

Electron spin control in Manganese doped GaAs/AlAs nanostructures — •Markus Kuhnert[1], Ilya A. Akimov[1], Vladimir L. Korenev[2], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany — [2]2A.F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

The field of spintronics, which in contrast to electronics, uses the spin instead of charge as information carrier, presents many interesting possibilities. For proper implementation of spintronic devices, research of adequate materials and methods is required. Here we present the results of our research into Manganese doped GaAs/AlAs quantum wells, which might offer long lived spin coherence as well as spin manipulation mediated by the magnetic Manganese ions. We use pump-probe Kerr effect measurement techniques and time resolved photoluminescence measurements to investigate properties such as spin coherence and spin lifetime of the Mn doped nanostructures. The temperatures at the time of measurement range from 2K to 8K. Further studies are done on optically induced EPR of the Mn ions by applying a microwave modulation to the excitation laser beam. Exchange interaction between the Manganese ions and electrons in the quantum well might function as a channel for spin manipulation or conservation.

MA 48.6 Thu 17:00 P1

Coherence Properties of Nitrogen Vacancy Centers in Nano Diamond — •Bernd Sontheimer, Niko Nikolay, Max Strauss, Andreas W. Schell, Janik Wolters, and Oliver Benson — Humbold Universität zu Berlin, Institut für Physik AG Nano-Optik, Newtonstr. 15, 12489 Berlin

The nitrogen vacancy (NV) center in diamond is a stable single photon emitter, combining optical transitions with a long-lived electronic spin with excellent coherence properties [1]. NV centers in nano diamonds are of special interest due to their integrability in photonic hybrid devices [2]. In our research we examine the coherence properties of nano diamonds based on optically detected magnetic resonance (ODMR) [3]. In particular the influence of surface treatments on the T_2 time is examined via spin-echo experiments [4]. Also a change of spectral diffusion is determined using correlation interferometry.

[1] G. Balasubramanian, et al., Ultralong spin coherence time in isotopically engineered diamond. Nat. Mater. 8, 383 (2009).
[2] J. Wolters, et al., Enhancement of the zero phonon line emission from a single nitrogen vacancy center in a nanodiamond via coupling to a photonic crystal cavity. Appl. Phys. Lett. 97, 141108 (2010).
[3] J. Wolters, et al., Measurement of the Ultrafast Spectral Diffusion of the Optical Transition of Nitrogen Vacancy Centers in Nano-Size Diamond Using Correlation Interferometry. Phys. Rev. Lett. 110, 027401 (2013).
[4] F. Jelezko, et al., Observation of Coherent Oscillations in a Single Electron Spin. Phys. Rev. Lett. 92, 076401 (2004).

MA 48.7 Thu 17:00 P1

Magnetic susceptibility of 2 dimensional electron gases with Rashba spin-orbit coupling — •Christiane Scholl, Tobias Hartenstein, and Hans Christian Schneider — TU Kaiserslautern

The transverse spin-spin correlation, or dynamical magnetic susceptibility, is an important quantity both from the experimental and theoretcial point of view. It determines light-scattering and spin noise spectra, as well as the dispersions of elementary excitations of the magnetic type, such as magnons or magneto-magnons. Here, we consider a two-dimensional electron gas including Rashba spin-orbit coupling and Coulomb interaction. We use a decoupling scheme to derive the equations of motion for the relevant Green functions. Approximating the full Coulomb matrix element by a local interaction U, a closed expression for the dynamic transverse magnetic susceptibility results, which we analyze numerically. We find a complex interplay of internal effective Rashba fields with the external magnetic field. Further, the elementary "magnetic" excitations arise from resonances of the magnetic suscpetibility that are very different from plasmon resonances [1,2] with Rashba spin-orbit coupling or magneto-magnon [3] resonances.

[1] M. Pletyukhov, V. Gritsev, Phys. Rev. B 74, 045307 (2006).
[2] S. M. Badalyan, A. Matos-Abiague, G. Vignale, and J. Fabian, Phys. Rev. B 79, 205305 (2009.)
[3] D. M. Edwards, J. Phys. C. 2, 84 (1969).

MA 49: Poster: Topological insulators (with O,TT)

Time: Thursday 17:00–20:00 Location: P1

MA 49.1 Thu 17:00 P1

Theoretical description of scanning gate microscopy on quantum Hall point contacts — •Martin Treffkorn and Bernd Rosenow — Institut für theoretische Physik, Universität Leipzig, Germany

In the integer quantum Hall regime, the concept of edge states allows to describe dissipationless, one-dimensional transport along the boundary of a sample. Recent experimental progress in the application of low-temperature scan-gate microscopy has allowed to image the spatial structure of edge states with high resolution [1]. To this end, a negatively charged scanning tip approaches a quantum point contact (QPC), such that changes in the spatial edge structure can be measured in the differential resistance of the QPC. The resistance only change when the tip induced change in electron density prevents an edge channel from passing through the point contact, since electrons may only travel along the quasi one dimensional channels at the edge. From the differential change of resistance versus the tip position one obtains a picture of the edge channels that are present in the system. We use a recursive Greens function algorithm to calculate the conductance of a QPC in the presence of a scanning tip. In our calculations we consider the existence of alternating compressible and incompressible strips across the system, paying particular attention to the influence of Coulomb interactions on the edge structure.

[1] N. Pascher, C. Rössler, T. Ihn, K. Ensslin, C. Reichl, and W. Wegscheider, arXiv:1309.4918 (2013).

MA 49.2 Thu 17:00 P1

Dirac and Weyl semimetal states in Na_3Bi from first principles — •Patrick Buhl, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Recently, the three-dimensional Dirac semimetal state was theoretically predicted to exist [1] and experimentally observed [2] in bulk Na_3Bi. Using first principles methods in combination with the Wannier functions technique [3], we construct and analyze the topological phase diagram of Na_3Bi as a function of spin-orbit strength and external exchange field. In particular we aim at realization of the Weyl semimetal phase in this material. The topological properties are characterized in terms of what computed from ab initio Chern and spin Chern numbers of the Berry curvature flux around the points of band degeneracy. Additionally, we consider finite slabs of Na_3Bi and focus on the electronic structure of the surface states in correlation to the bulk topological phase diagram. Financial support by the HGF-YIG Programme VH-NG-513 is gratefully acknowledged.

[1] Z. Wang *et al.*, Phys. Rev. B **85**, 195320 (2012)
[2] Z.K. Liu *et al.*, arXiv:1310.0391 (2013)
[3] www.flapw.de

MA 49.3 Thu 17:00 P1

Dielectric Function of the Topological Surface States of Bi_2Se_3 — •Markus Heinemann, Christian Franz, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, 35392 Giessen, Germany

We investigate the material system Bi_2Se_3 which recently has been discovered to belong to the new class of topological insulators (TI). In this TI, robust surface states located in the insulating band gap of the bulk are protected by time-reversal symmetry and consist of a single Dirac cone at the Γ-point [1]. We use density functional theory to investigate the electronic structure and dielectric function of Bi_2Se_3 by first principles. In our calculations we study the bulk material and the Se terminated surface of Bi_2Se_3 which we simulate by a slab model and examine the effect of the slab thickness, i.e. the number of atomic layers. The essential effect of spin-orbit-coupling for the topological state and thus on the electronic and dielectric properties is presented by comparing calculations with and without this feature.

[1] H. Zhang, C.-X. Liu, X.-L. Qi, X. Dai, Z. Fang, and S.-C. Zhang, Nature Phys. 5, 438 (2009)

MA 49.4 Thu 17:00 P1

Topological Insulator Nanowires by Chemical Vapour Deposition — •Piet Schönherr and Thorsten Hesjedal — Department of Physics, Clarendon Laboratory, University of Oxford, Oxford, OX1 3PU, United Kingdom

Topological insulators (TIs) are a new state of quantum matter which insulates in the bulk and conducts on the surface. The study of bulk TIs has been hindered by high conductivity inside the bulk, arising from crystalline defects. Such problems can be tackled through compositional engineering or the synthesis of TI nanomaterials. We combined both approaches in a systematic study of various growth parameters to achieve uniform, high purity nanowires with high substrate coverage.

The highlight of this study is the development of a new growth route for nanowires, based on a TiO_2 catalyst rather than the conventional Au. Comparative studies demonstrate that Au significantly contaminates the nanowires, whereas TiO_2 stays well separated. Details of the Au and TiO_2-catalysed growth mechanism were investigated. For Au it was found that the growth mechanism is vapour-liquid-solid. For TiO_2 nanoparticles, in contrast, the growth mechanism can be described in the vapour-solid scheme.

Nanowires of the doped compound $(Bi_{0.78}Sb_{0.22})_2Se_3$ were studied using synchrotron radiation. It was discovered that the material mainly adopts an orthorhombic phase known from Sb_2Se_3. The Raman spectrum is reported and matched with the structural information for the first time. Further, a method to control the length and diameter of Bi_2Se_3 nanowires through laser-cutting was developed.

MA 49.5 Thu 17:00 P1

Strained HgTe shell on CdTe nanowires grown by Au catalyst MBE — •Maximilian Kessel, Rebekka Pfeuffer, Claus Schumacher, Hartmut Buhmann, and Laurens W. Molenkamp — Experimental Physics 3, University of Würzburg, Germany

The topological insulator properties of 2D and strained 3D HgTe layers have attracted strong attention over the past years. One interesting question that rose was how the TI state evolves in quasi-one dimensional geometry. Here, we present the first realization of a strained HgTe shell on CdTe nanowires.

Doped GaAs wafers are used as substrates for the nanowire growth in a multi-chamber ultra-high vacuum system. The CdTe growth is seeded by liquid Au/Ga eutectic droplets. For straight, uniform and smooth shaped CdTe wires, a special growth start is performed and the substrate temperature is hold within narrow limits. The wires have a diameter of 30 to 100 nm and grow along the [111]B direction up to a length of 3 μm. The ensemble of CdTe wires is used as substrate for HgTe molecular beam epitaxy. Shell and core of the nanowires are characterized by electron and X-ray diffraction. The radial heterostructures show strained crystalline structure. Transport characterization measurements on separated radial HgTe/CdTe heterostructures are done at low temperature.

MA 49.6 Thu 17:00 P1

Weak anti-localization in HgTe quantum wire arrays — •Johannes Ziegler[1], Sabine Weishäupl[1], Christopher Ames[2], Christoph Brüne[2], Harmut Buhmann[2], Laurens W. Molenkamp[2], and Dieter Weiss[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [2]Physikalisches Institut (EP III), Universität Würzburg, Germany

We present our progress in fabricating quasi-1D quantum wire arrays in inverted HgTe quantum wells, being a 2D topological insulator. These quasi-1D quantum wire arrays were fabricated with widths between 120 nm and 250 nm. Our experiments focus on phase-coherent effects, like weak anti-localization and weak-localization, in both wire arrays and 15 and 40 μm wide Hall-bars. From these measurements we extract the phase-coherence length l_ϕ and the spin-relaxation length l_{SO}.

Our work is motivated by a proposal for all-electrical detection of the relative spin-orbit interaction strength α / β [1,2], where α is the Rashba and β the Dresselhaus spin-orbit parameter. A key requirement for this method is the transition from weak anti-localization (WAL) to weak localization (WL) through 1D confinement. The analysis of these characteristic lengths allows us to check when the suppression of WAL occurs.

[1] M. Scheid *et al.*, Phys. Rev. L **101**, 266401 (2008).
[1] M. Scheid *et al.*, Semicond. Sci. Technol. **24**, 064005 (2009).

MA 49.7 Thu 17:00 P1

Magnetotransport and ac conductivity in 2D and 3D topological insulators — •Christian Michel and Ewelina M. Hankiewicz — Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany

We study theoretically Landau level structure and optical selection rules in 2D and 3D TIs. Our focus is to find the features which are specific to the Dirac physics. We show that the optical selection rules are different for the particle-hole symmetric Dirac model in comparison with the particle-hole asymmetric models. We explain the influence of dimensionality on the characteristic features of optical selection rules.

We acknowledge grant HA 5893/4-1 within SPP 1666.

MA 49.8 Thu 17:00 P1

Ferromagnetic contacts on topological insulators: Lithographic realization on strained 3-dimensional HgTe — •Kalle Bendias, Erwann Bocquillon, Simon Hartinger, Christoph Brüne, Hartmut Buhmann, and Laurens Molenkamp — EP3, Physikalisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg

Topological insulators are a new class of material with insulating bulk and conducting Dirac-like surface states. These states are associated with spin-momentum locking, which is supposed to lead to numerous applications in spintronics [1].

Here we report on lithographic ways to realize the concept of spin injection and detection into the Dirac-like surface states of the 3-dimensional topological insulator HgTe. We discuss fabrication challenges such as unstrained deposition of ferromagnetic material and the realization of a diffusion barrier on the high temperature-sensitive HgTe material system.

[1]C. Brüne, et. al, Phys. Rev. Lett. 106, 126803 (2011)

MA 49.9 Thu 17:00 P1

Transport properties of the high mobility topological insulator HgTe — •Jonas Wiedenmann[1], Cornelius Thienel[1], Christopher Ames[1], Christopher Brüne[1], Steffen Wiedmann[2], Hartmut Buhmann[1], and Laurens Molenkamp[1] — [1]Universität Würzburg, Würzburg, Deutschland — [2]Radboud Universität Nijmegen, Nijmegen, Holland

It has been demonstrated recently, that the semimetal HgTe opens a band gap of approximately 20 meV when grown strained on a CdTe substrate and thus becomes a three dimensional topological insulator (3D TI)[1].

We show that it is possible to increase the mobility of the surface states by an order of magnitude, if HgTe is sandwiched between epitaxial layers of HgCdTe. The topological insulator is investigated in transport measurements at low temperatures and magnetic fields up to 30 T. Through the enhanced surface mobilites we are able to observe a Dirac specific quantum hall effect. The experimental data suggest, that it has to be discussed within a two surface model for Dirac fermions.

[1] C. Brüne et al., Phys. Rev. Lett. 106, 126803 (2011)

MA 49.10 Thu 17:00 P1

Heteroepitaxial Li_2IrO_3 Thin Films Grown by Pulsed Laser Deposition — •Marcus Jenderka, Heiko Frenzel, Rüdiger Schmidt-Grund, Marius Grundmann, and Michael Lorenz — Institut für Experimentelle Physik II, Universität Leipzig, Linnéstraße 5, D-04103 Leipzig. Germany

The layered perovskite oxides A_2IrO_3 (A = Na, Li) have been studied in recent years in terms of a physical realization of spin-liquid [1] and topological insulator [2] phases, desired within certain quantum computation proposals. We report on the pulsed laser deposition of heteroepitaxial Li_2IrO_3 films on ZrO_2:Y(001) single crystalline substrates. As in Na_2IrO_3 [3], X-ray diffraction confirms a preferential (001) out-of-plane crystalline orientation with a defined in-plane epitaxial relationship. Resistivity between 35 and 300 K is dominated by a three-dimensional variable range hopping mechanism. Infrared optical transmission from 0 to 1.85 eV, measured by Fourier transform infrared spectroscopy (FTIR), reveals a small optical gap $E_{go} \approx 300$ meV together with a splitting of the $5d$-t_{2g} manifold caused by the interplay of spin-orbit coupling and electronic correlations. By means of infrared spectroscopic ellipsometry, the dielectric function (DF) is presented in the spectral range between 0.03 and 3.50 eV. The calculated absorption coefficient confirms the value for E_{go}.

[1] J. Chaloupka *et al.*, Physical Review Letters **105**, 027204 (2010).
[2] H.-S. Kim *et al.*, Physical Review B **87**, 165117 (2013).
[3] M. Jenderka *et al.*, Physical Review B **88**, 045111 (2013).

MA 49.11 Thu 17:00 P1

Epitaxial growth of $LaNiO_3$ and $LaAlO_3$ thin films and multilayers by PLD — •Haoming Wei, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany

As predicted by recent theoretical study, the superlattices (SLs) consisting of paramagnetic metal $LaNiO_3$ (LNO) and band insulator $LaAlO_3$ (LAO) may exhibit exotic topological phases[1]. We have grown LNO, LAO films and LNO/LAO heterostructures by plused laser deposition (PLD). All the films show good out-of-plane and inplane crystalline orientation and definite epitaxial relationship. The lattice constant and strain of LNO films could be controlled by adjusting growth conditions. The LNO films have an excellent metallic conductivity and the resistivity is related to strain. The low resistivity is about 300$\mu\Omega$·cm at 300 K, which is low enough for use as an electrode material. The LAO films obtained by interval PLD exhibit terraced surface even when grown at a low temperature. The height of the terraces is about 0.4 nm in accord with the calculated result from XRD pattern. Further, LNO/LAO multilayer structures were fabricated. Atomic force microscopy (AFM) together with reflection high-energy electron diffraction (RHEED) images show that the multilayers have a smooth surface with the root mean square roughness about 3.2 nm.

[1] K. Y. Yang, et al. Physical Review B 84, 201104(R) (2011).

MA 49.12 Thu 17:00 P1

Combined XMCD and STS study of transition metal adatoms adsorbed on the surface of prototypical 3D topological insulators — •Jonas Warmuth[1], Martin Vondráček[2], Matteo Michiardi[3], Lucas Barreto[3], Cinthia Piamonteze[4], Andreas Eich[1], Alexander Khajetoorians[1], Jian-Li Mi[3], Bo Brummerstedt Iversen[3], Philip Hofmann[3], Jens Wiebe[1], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, Uni Hamburg, Germany — [2]Institute of Physics ASCR, Prague, Czech Republic — [3]iNano, Aarhus University, Denmark — [4]Laboratory of Condensed Matter Physics, PSI, Switzerland

The spin of Dirac electrons in topological surface states is rigidly locked to the direction of their momentum leading, e.g., to prohibited backscattering. Their interaction with magnetic impurities is currently a matter of debate, because it can destroy this effect, heavily depending on the magnetic properties of the impurities. Using x-ray magnetic circular dichroism techniques we investigated 3d transition metal adatoms adsorbed on the surface of different prototypical 3D topological insulators. We compare our results to crystal field multiplet calculations [1] of the 3d states. For some of the adatom species, we find a considerable magnetic anisotropy, which depends crucially on the coupling of their 3d states to the substrate electrons. Furthermore, we investigate the interaction of the adatoms and the Dirac electrons by Fourier-transform scanning tunneling spectroscopy [2], which reveals shifts of the linear dispersion due to surface doping effects.

[1] J. Honolka et al., PRL 108, 256811 (2012)

MA 50: Topological Insulators (jointly with DS,HL,O,TT)

Time: Friday 9:30–12:00 Location: HSZ 04

MA 50.1 Fri 9:30 HSZ 04

Experimental characterization and simulation of quasi-particle-interference in the Bi-bilayer topological insulator — •Matteo Michiardi[1], Andreas Eich[2], Gustav Bihlmayer[3], Alex A. Khajetoorians[2], Jens Wiebe[2], Jianli Mi[4], Bo B. Iversen[4], Philip Hofmann[1], and Roland Wiesendanger[2] — [1]Department of physics and astronomy, Aarhus University, Denmark — [2]Institute of Applied Physics, University of Hamburg, Germany — [3]Peter Grünberg Institut, Forschungszentrum Jülich, Germany — [4]Center for Materials Crystallography, Aarhus University, Denmark

Topological insulators (TI) are a new class of materials that host gapless surface states with spin helicity. While several 3D TIs have been discovered, the interest in 2D TI systems that can host topological edge state is rising. A single bilayer of bismuth is predicted to be such a 2D TI. Here we present an experimental and theoretical study of a Bi-bilayer grown on 3D TI Bi_2Se_3. The use of Bi_2Se_3 as substrate allows the epitaxial growth of the bilayer in the rhombohedral structure, as shown by Scanning Tunnelling Microscopy. We calculate the band structure of the Bi-bilayer/Bi_2Se_3 system by Density Function Theory (DFT) and experimentally study the quasi particle interference (QPI) on the bilayer. In order to clarify the scattering channels responsible for the QPI, we perform simulations based on the Joint Density of States method starting from our DFT calculations. The comparison with the experimental results reveals a good match for a wide range of binding energies for both occupied and unoccupied states.

MA 50.2 Fri 9:45 HSZ 04

Quasiparticle self-consistent *GW* study of bismuth under strain — •Irene Aguilera, Christoph Friedrich, Gustav Bihlmayer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

It has been recently claimed on the basis of ARPES measurements that bulk bismuth is a topological semimetal. The discrepancies between this result and previous *ab-initio* calculations were attributed to the failure of density functional theory (DFT) in the prediction of band gaps, because the topological or trivial character of Bi depends only on the "sign" of the very small direct band gap at the L point. We show that bulk Bi is indeed predicted by DFT in the local-density approximation (LDA) to be a trivial semimetal, with a surprisingly overestimated gap at L. We have performed quasiparticle self-consistent *GW* (QS*GW*) calculations for bulk bismuth that support its trivial character. The QS*GW* gap at L as well as the energy overlap between the electron and hole pockets are in much better agreement with experiments than the LDA ones. Thus, the QS*GW* approach appears as the right tool to study the trivial-to-topological transition that Bi experiences under stress, as a result of a change of sign of the gap at L. We have analyzed the effect of strain on the topological properties of bulk Bi. Whereas LDA predicts that an impractical stress is needed for such a transition, QS*GW* shows that bulk Bi becomes a topological semimetal already under very small stress. This work is supported by the Helmholtz Virtual Institute for Topological Insulators (VITI).

MA 50.3 Fri 10:00 HSZ 04

Combined STM/STS- and ARPES-investigation of the quaternary Topological Insulator $Bi_{1.5}Sb_{0.5}Te_{1.8}Se_{1.2}$ — •Thomas Bathon[1], Felix Reis[1], Christoph Seibel[2], Hendrik Bentmann[2], Paolo Sessi[1], Friedrich Reinert[2], and Matthias Bode[1] — [1]Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Physikalisches Institut, Experimentelle Physik VII, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

We present a combined scanning tunneling microscopy/spectroscopy (STM/STS) and angular-resolved photoemission spectroscopy (ARPES) characterization of the electronic properties of the quaternary compound $Bi_{1.5}Sb_{0.5}Te_{1.8}Se_{1.2}$. ARPES-data evidence that this compound is still a Topological Insulator (TI) with a single Dirac cone, which is characteristic for the Bi_2X_3-class. The topological properties of the surface state, i.e. forbidden backscattering, have been confirmed by Fourier-transformed differential conductance (dI/dU) maps. Measurements performed both above and below the Fermi level allow us to determine the energy dispersion relation, the carrier velocity, and—by extrapolation to zero momentum—the position of the Dirac point. The observed scattering vectors are not as well-defined as those observed in binary compounds, probably due to substitutional disorder which results in a spatial fluctuation of the chemical potential. Our investigations illustrate how the properties of the well-known TI Bi_2Te_3 can be changed by chemical substitution.

MA 50.4 Fri 10:15 HSZ 04

Surface and bulk contributions to the electronic structure of the topological insulator Sb_2Te_3(0001) — •Christoph Seibel[1,2], Hendrik Bentmann[1,2], Henriette Maass[1,2], Jürgen Braun[3], Jan Minár[3], Kenya Shimada[4], and Friedrich Reinert[1,2] — [1]Experimentelle Physik VII, Universität Würzburg, D-97074 Würzburg — [2]Gemeinschaftslabor für Nanoanalytik, Karlsruher Institut für Technologie KIT, D-76021 Karlsruhe — [3]Department Chemie, Physikalische Chemie, Universität München, Butenandtstraße 5-13, D-81377 München — [4]Hiroshima Synchrotron Radiation Center, Hiroshima University, Higashi-Hiroshima 739-0046, Japan

Photon energy dependent angle-resolved photoemission measurements were performed to disentangle surface and bulk contributions to the electronic structure of the 3D topological insulator (TI) Sb_2Te_3. We discover a penetration of the topological surface state (TSS) into the bulk valence band regime where it coexists with bulk states without considerable hybridization. Our results indicate an emerging $k_\perp$-dispersion of the TSS at higher binding energies, which we attribute to an increasing bulk character. These observations deviate from previous findings for the isostructural TIs Bi_2Se_3 and Bi_2Te_3. Our results are supported by fully relativistic one-step photoemission calculations.
[1] Seibel *et al.* PRB 86, 161105(R) (2012)

15 min. break

MA 50.5 Fri 10:45 HSZ 04

Spin-dependent unoccupied electronic structure of the topological insulator Sb_2Te_3 — •Anna Zumbülte[1], Anke B. Schmidt[1], Markus Donath[1], Peter Krüger[2], Gregor Mussler[3], and Detlev Grützmacher[3] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Germany — [2]Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Germany — [3]Peter Grünberg Institut, Forschungszentrum Jülich, Germany

Studies on three-dimensional topological insulators focus mainly on the well-known systems of Bi_2Se_3 and Bi_2Te_3 and the related ternary compounds. Theoretical predictions of chalcogenides as topological insulators with a single Dirac cone [1] include an additional compound, Sb_2Te_3. There, due to p-type doping of the available samples, the Dirac point lies above the Fermi level, making it inaccessible to photoemission experiments unless the surface is modified with an adsorbate [2]. Consequently, the electronic structure of this system has been left almost unstudied.

We present spin- and angle-resolved inverse-photoemission measurements of the unoccupied electronic states of Sb_2Te_3. In addition to the Dirac state, further spin-dependent features have been obtained which show a distinct Rashba splitting. The experimental data will be discussed along with bandstructure calculations.

[1] H. Zhang *et al.*, Nat. Phys. **5**, 438 (2009)
[2] C. Seibel *et al.*, Phys. Rev. B **86**, 161105 (2012)

MA 50.6 Fri 11:00 HSZ 04

Comparitive study of the ternary topological insulators Bi_2Se_2Te and Bi_2Te_2Se — •Felix Reis[1], Thomas Bathon[1], Christoph Seibel[2], Hendrik Bentmann[2], Paolo Sessi[1], Friedrich Reinert[2], and Matthias Bode[1] — [1]Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Physikalisches Institut, Experimentelle Physik VII, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

The 3D topological insulators Bi_2Se_2Te and Bi_2Te_2Se have been investigated by combining the complementary experimental techniques scanning tunneling microscopy (STM/STS) and angular-resolved photoemission spectroscopy (ARPES). With low temperature STM/STS technique we investigate the structural and electronic properties of both systems. Fourier-transformed quasi-particle interference (QPI) maps give access to the scattering events within the topological surface state. Taking QPI maps for several energies allows us to obtain information on the position of the Dirac point and the carrier velocity by fitting the linear energy dispersion relation of the Dirac fermions. These results will be compared with the band structure as obtained by ARPES measurements.

MA 50.7 Fri 11:15 HSZ 04

A large-energy-gap oxide topological insulator based on the superconductor BaBiO3 — •Binghai Yan[1,2,3], Martin Jansen[1], and Claudia Felser[1,3] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden — [2]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden — [3]Institute for Inorganic and Analytical Chemistry, Johannes Gutenberg University of Mainz, 55099 Mainz

Topological insulators are a new class of quantum materials that are characterized by robust topological surface states (TSSs) inside the bulk-insulating gap, which hold great potential for applications in quantum information and spintronics as well as thermoelectrics. One major obstacle is the relatively small size of the bulk bandgap, which is typically around 0.3eV for the known topological insulator materials. Here we demonstrate through ab initio calculations that a known superconductor BaBiO3 (BBO) with a Tc of nearly 30 K emerges as a topological insulator in the electron-doped region. BBO exhibits a large topological energy gap of 0.7 eV, inside which a Dirac type of TSSs exists. As the first oxide topological insulator, BBO is naturally stable against surface oxidization and degradation, distinct from chalcogenide topological insulators. An extra advantage of BBO lies in its ability to serve as an interface between TSSs and superconductors to realize Majorana fermions for future applications in quantum computation.

Reference: B. Yan, M. Jansen, C. Feler, Nature Physics 9, 709*711 (2013) (arXiv:1308.2303).

MA 50.8 Fri 11:30 HSZ 04

Topological surface states of HgTe and Heulser compounds — •Shu-Chun Wu[1], Binghai Yan[1,2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany. — [2]Max Planck Institute for Physics of Complex Systems, Dresden, Germany.

We studied the topological electronic structures of HgTe and half Heusler compounds (e.g.: XYZ, X = rare earth elements, Y = trasition metal and Z = main group elements) by both *ab initio* calculations. The topological surface structures were investigated by the Wannier function based tight-binding method. The effects of external strains induced from the substrate and surface terminations are taken into account by the atomic positions. Our results agree well with recent photoemission experiments.

MA 50.9 Fri 11:45 HSZ 04

Sputter Deposition of Half-Heusler Topological Insulators — •Benedikt Ernst, Daniel Ebke, Stanislav Chadov, Gerhard Fecher, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany

Heusler compounds have exhibited manifold physical properties in the recent years and attracted a lot of interest in the field of spintronic applications due to their half-metallic properties. Recently, a topological insulating state has been predicted by theory for some of these compounds.

In this work, we have prepared Heusler materials such as LaPdBi and LaPtBi for which a topological insulating behavior was predicted. Co-deposition by DC- and RF magnetron sputtering was used to prepare corresponding thin films. To realize an epitaxial film growth in the crystallographic $C1_b$ structure on MgO-substrates, a buffer layer was applied and optimized. Initial transport properties will be discussed with regard to the film composition and the crystallographic properties.

MA 51: Electron Theory of Magnetism

Time: Friday 9:30–12:00 Location: HSZ 401

MA 51.1 Fri 9:30 HSZ 401

A coherent relativistic description of spin and orbital magnetisation of solids — •Hubert Ebert and Sergiy Mankovsky — Dept. Chemie/Physikalische Chemie, Universität München, Butenandtstr. 5-13, D-81377 München, Deutschland

Recently, a definition for the orbital magnetisation of magnetic solids was suggested using a Bloch representation of the electronic structure [1]. Results for the spin-orbit induced magnetisation of Fe, Co and Ni based on this approach were presented by various authors [2]. To avoid the approximations and limitations of these investigations we present a coherent relativistic definition for the total magnetisation that is derived from the interaction of the total electronic current density with an external magnetic vector potential. Representing the electronic structure in terms of the Green function using the KKR band structure method leads to two terms that can be related to the Van Vleck and Landau contributions of the magnetic susceptibility [3]. A decomposition of the total magnetisation may be obtained by subtracting the spin part, that can be unambiguously determined, from the total magnetisation. Another route is to make use of the Gordon decomposition of the total electronic current density leading in a natural way to a spin and orbital contribution. Numerical results for the elemental ferromagnets Fe, Co and Ni will be presented and discussed.

[1] J. Shi et al., PRL **99**, 197202 (2007)
[2] D. Ceresoli et al. PRB **81** 060409(R) (2010);
M. G. Lopez et al., PRB **85** 014435 (2012)
[3] S. Mankovsky and H. Ebert, PRB **74**, 054414 (2006)

MA 51.2 Fri 9:45 HSZ 401

Exchange interactions and Curie temperature of MnSi: A density functional study — •Giovanna Lani, Phivos Mavropoulos, Gustav Bihlmayer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

We present a theoretical investigation of zero and finite temperature properties of bulk MnSi in the B20 structure. MnSi is known to pose a theoretical challenge, as its magnetic moment is overestimated by a factor two within the LDA and GGA approximations to DFT. Therefore, employing two different all-electron approaches, namely the FLAPW and KKR methods, we investigate how constraining the magnetic moment to the experimental value affects the electronic structure of MnSi. By mapping the results of DFT calculations onto a Heisenberg Hamiltonian, we extract the exchange parameters. We find that they exhibit long-range oscillations and we argue that while some of their features are independent of the value of the magnetic moment, others are not and this can be attributed to changes in the Fermi surface topology as a function of the moment. The Curie temperature, estimated via a Monte Carlo method, agrees with the available measurements only when the moment is constrained to the experimental value. This finding is further validated by including longitudinal moment fluctuations within a static mean field theory with a KKR-CPA disordered local moment calculation in the spirit of the Hubbard III approximation.

MA 51.3 Fri 10:00 HSZ 401

Ab-initio spin dynamics for clusters — •Laszlo Udvardi, Levente Rozsa, and Laszlo Szunyogh — Dept. of Theor. Phys., TU Budapest, Hungary

Ab initio atomistic spin dynamics simulations provide a way to theoretically investigate systems containing from a few dozen to a few thousand atoms. These methods are based on the numerical solution of the stochastic Landau-Lifshitz-Gilbert (LLG) equation. In most of the cases the torque driving the motion of the spins is determined by means of a Heisenberg model with ab-inito parameters.

In the present work we propose a method where the torque is calculated directly from the density functional theory without the need of underlying Heisenberg model. The electronic structure of the cluster is determined by applying the embedded cluster method using the relativistic Korringa-Kohn-Rostoker method. The torque rotating the spins in the cluster is calculated within the framework of the magnetic force theorem as the derivatives of the band energy with respect of the transverse change of the magnetization.

The method is applied for a 10 atoms long linear Co chain on Au (001) surface. The magnetic ground state is turned out to be a spin spiral due to the Dzyaloshinsky-Moriya interaction. The results of the simulations are in good agreement with the results of the analytically solvable Heisenberg chain with nearest neighbor exchange coupling. The behaviour of the switching between the two degenerate ground states was also studied by means of both ab-initio and model calculations.

MA 51.4 Fri 10:15 HSZ 401

The phase diagram of the xxz model on the triangular lattice — •Daniel Sellmann, XUE-FENG ZHANG, and Sebastian Eggert — University of Kaiserslautern, Germany

The Heisenberg model on the triangular lattice was proposed as the first example of a spin-liquid by Anderson in the early 70s. Even though the isotropic Heisenberg model is by now well understood and known *not* to be a spin-liquid in the modern sense, there are still no quantum many-body simulations which have explored the full phase diagram of the xxz model on the triangular lattice. We now present DMRG calculations on order parameters and entanglement measures in order to establish the quantitative phase diagram as a function of field and Ising anisotropy. The transition to the xy-phase is always first order, but there is a novel tricritical point at the transition to the 1/3-Neel phase. The neel phase is connected to two different supersolid-type phases by second order phase transitions, one of which curiously turn first oder in the Ising limit.

MA 51.5 Fri 10:30 HSZ 401

Ab initio calculation of crystal field parameters for single Holmium atoms at a surface — •Martin Hoffmann[1,2], Matthias Geilhufe[2], Sergey Ostanin[2], Wolfram Hergert[1], Ingrid Mertig[1,2], and Arthur Ernst[2,3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [3]Wilhelm-Ostwald-Institut für Physikalische und Theoretische Chemie, Universität Leipzig, Germany

The direction of the magnetic moments of atoms at a surface depends strongly on the anisotropy of the underlying material. In most cases, the determination of the simple uniaxial anisotropy is sufficient to describe the orientation of the moments. However, this is only the first term in the more general crystal field Hamiltonian $\mathcal{H}$. Higher terms couple e.g. different sublevels of the energy spectrum of an adsorbed atom.

Based on the electronic density of the substrate and the ad-atom, the parameters for this $\mathcal{H}$ can be calculated by ab-initio methods. We will present the implementation of this scheme for the Korringa-Kohn-Rostoker Green's function method.

As application example, we calculated for a single Holmium (Ho) atom at a Pt(111) surface at first the position and the electronic and magnetic properties. With theses quantities we obtained the crystal field parameters for $\mathcal{H}$, which can be further solved by exact diagonalization for the magnetic states of Ho. The resulting energy splitting is in very good agreement with experimental results.

MA 51.6 Fri 10:45 HSZ 401

Crystal field and magnetism with Wannier functions: rare earth ions in oxides — •Pavel Novak — Institute of Physics ASCR, Cukrovarnicka 10, 162 00 Praha 6, Czech Republic

During the last two years we developed a scheme, which was successfully used to determine the crystal field parameters of trivalent rare earth ions in oxides. These parameters were then inserted in atomic-like program which, besides the crystal field, takes into account the 4f-4f electron repulsion, spin-orbit and Zeeman interactions. The agreement of the calculated and experimental splitting of rare earth multiplets was very good (within meV) and also magnetism of the RE multiplets was correctly described. The method was already applied to more than fifty systems: rare earth containing aluminates, galates, cobaltites and manganites with orthorhombic perovskite structure, yttrium aluminium and lutetium aluminium garnets containing rare earth impurities and rare earth layered hexagonal cobaltates. In the present contribution the method is reviewed and applied to selected rare earth compounds. Accuracy and limits of the method is also discussed.

P. Novak, K. Knizek and J. Kunes, Phys. Rev. B 87, 205139 (2013). P. Novak, K. Knizek, M. Marysko, Z. Jirak and J. Kunes, J. Phys.: Condens. Matter 25, 446001 (2013).

MA 51.7 Fri 11:00 HSZ 401

Electronic structure and magnetic properties of Cr-Sb compounds with NiAs structure — •Sergiy Mankovsky[1], Gerhard Kuhn[1], Svitlana Polesya[1], Matthias Regus[2], Wolfgang Bensch[2], and Hubert Ebert[1] — [1]Dept. Chemie/Physikalische Chemie, Universität München, Butenandtstr. 5-13, D-81377 München, Deutschland — [2]Institut für Anorganische Chemie, Christian-Albrechts-Universität zu Kiel, Max-Eyth-Str. 2, D-24118 Kiel, Deutschland

The electronic structure and magnetic properties of binary Cr-Sb compounds with NiAs crystal structure have been investigated via Density Functional Theory (DFT) band structure calculations using the Korringa-Kohn-Rostoker Green function (KKR-GF) method. The finite temperature magnetic properties were studied by means of Monte Carlo simulations based on the Heisenberg model with the exchange coupling parameters calculated from first principles. The modification of the properties of Cr-Sb compounds due to substitution of Cr by 3*d*-elements is also studied. In particular, the magnetic phase diagram of the $Cr_{1-x}Mn_xSb$ alloy system with NiAs structure was calculated. At low temperatures, it shows stable collinear FM and AFM states for the Mn- and Cr-rich sides, respectively, and a non-collinear magnetic structure in the middle region of concentrations. These findings are fully in line with experimental data.

MA 51.8 Fri 11:15 HSZ 401

Electronic structure and magnetic anisotropy of $Sm_2Fe_{17}N_x$ — •Masako Ogura[1,2] and Hisazumi Akai[3] — [1]Ludwig-Maximilians-University Munich, Munich, Germany — [2]Osaka University, Toyonaka, Japan — [3]University of Tokyo, Kashiwa, Japan

Electronic structure and magnetic properties of $Sm_2Fe_{17}N_x$ are studied on the basis of the first-principles electronic structure calculation in the framework of the density functional theory. It is experimentally known that the magnetism of Sm_2Fe_{17} is enhanced when N is added. In the present study, the magnetic properties of the system as a function of the N concentration are discussed. Although the main origin of the enhancement of the magnetism is the volume enhancement due to the addition of N, the hybridization between the Fe 3d states and the N 2p states also plays an important roll. In addition, the electron transfer between Sm and N affects the magnetic anisotropy.

MA 51.9 Fri 11:30 HSZ 401

Fast algorithm for conductance of layered systems — •Vaclav Drchal[1], Josef Kudrnovsky[1], and Ilja Turek[2] — [1]Inst. of Physics, Acad. Sci., Praha, Czech Republic — [2]Inst. of Physics of Materials, Brno, Czech Republic

We developed a highly efficient method to calculate the conductance of disordered multilayer systems that can be represented by lateral supercells with random occupation of lattice sites by atoms. Stacking of supercells in the growth direction is arbitrary. The method employs the surface Green functions and it is of $O(L)$ type, where L is the number of layers. For large L the conductance behaves as $C(L) = \sigma L$, where σ is a longitudinal conductivity. The method is illustrated on disordered magnetic alloys and on a graphene sheet with adsorbed magnetic atoms.

MA 51.10 Fri 11:45 HSZ 401

The Fermi-sea term in relativistic LMTO transport theory for random 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 formulation of the so-called Fermi-sea contribution to the conductivity tensor of spin-polarized random alloys within the fully relativistic tight-binding LMTO method and the coherent potential approximation (CPA). We show that the configuration averaging of this contribution is surprisingly simple, since it leads to the CPA-vertex corrections that are solely due to the energy dependence of the average single-particle propagators. Moreover, we prove that the Fermi-sea term is indispensable for the invariance of the anomalous Hall conductivities with respect to the particular LMTO representation used in numerical implementation. The calculations for ferromagnetic 3*d* metals (Fe, Co, Ni) and their selected random binary alloys will be presented and their results will be compared with the previous study [1] based only on the Fermi-surface contribution. [1] I. Turek et al., Phys. Rev. B 86, 014405 (2012).

MA 52: Magnetic Materials IV

Time: Friday 9:30–11:30 Location: HSZ 403

MA 52.1 Fri 9:30 HSZ 403

Reduced Hyperfine Magnetic Field and Spin Reorientation in FeNCN — •Marcus Herlitschke[1,2], Ludwig Stork[3], Benedikt Klobes[1], Andrei Tchougreeff[3], Richard Dronskowski[3], and Raphael Hermann[1,2] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, D-52425 Jülich (Germany) — [2]Faculté des Sciences, Université de Liège, B-4000 Liege (Belgium) — [3]Chair of Solid-State and Quantum Chemistry, RWTH Aachen, D-52056 Aachen (Germany)

The novel anti-ferromagnetic compound FeNCN which can be considered the nitrogen containing analogue of iron(II) oxide, FeO, was initially synthesized in 2009 [1,2]. We studied this three-dimensional extended non-oxidic framework comparatively to the related iron monoxide using different nuclear resonant methods and vibrating sample magnetometry. Although our results indicate some similarities between both compounds based on the bonding and the local environment of iron, Fe-57 Mössbauer spectroscopy revealed an interesting and unexpected behavior of the hyperfine parameters below the Néel temperature of 350 K. As expected, the hyperfine magnetic field initially increases with decreasing temperature, but reaches a maximum around 295 K and then starts decreasing. In addition to it, the iron spins rotate away from 90 to 60 degrees relative to the *c*-axis.

[1] X. Liu *et al.*, J. Phys. Chem. C, 112(29):11013, 2008.
[2] X. Liu *et al.*, Chem. Eur. J., 15(7):1558, 2009.

MA 52.2 Fri 9:45 HSZ 403

Fabrication, magnetic properties and domain structures of patterned Permalloy near the transcritical state — •Gregor Büttel, Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P. O. Box 151150, D66041, Saarbrücken, Germany

Permalloy (Ni81Fe19) films and laterally patterned structures were investigated for their use in giant magneto-impedance sensors. Such films are known to show a transcritical state marked by strong perpendicular anisotropy and stripe domains above a critical film thickness of a few 100 nm when grown by sputtering deposition. An in-plane magnetic field was applied and sputtering parameters were optimized to avoid the stripe domains and keep the in-plane coercivity of such films low enough for sensor applications. Effects of these fabrication procedures were studied by structural analysis by AFM and SEM and magnetization curves are recorded by MFM and VSM/magnetometry.

MA 52.3 Fri 10:00 HSZ 403

Anisotropy Measurements on YCo_5 and $(Y, X)(Co, Z)_5$ materials at various temperatures — •Christoph Andreas Schwöbel, Michael Kuzmin, Konstantin Skokov, and Oliver Gutfleisch — TU Darmstadt, Materialwissenschaften, 64287 Darmstadt

The presented work is part of the ROMEO consortium (abbrev. for Replacement and Original Magnet Engineering Options), which is supported by the seventh framework program of the European Union. One objective is to remove, or greatly reduce, the need for heavy rare earths in high performance permanent magnets by novel microstructural engineering strategies. The other goal is to develop a magnet containing no rare earth at all. Both strategies aim at drastically reducing Europe's dependence on rare earth supplies from China.

This work focuses on heavy rare earth free, highly anisotropic materials, which potentially exhibit a high coercivity, if manufactured into a magnet. Materials of the $CaZn_5$-type are investigated. They show high anisotropy constants due to their hexagonal crystal structure. These constants were measured in a high field PPMS at various temperatures on single crystals. Based on our first measurements on YCo_5, we grew single crystals modifying both the Y and the Co site with other elements and systematically investigated the anisotropy, magnetization and Curie temperature.

MA 52.4 Fri 10:15 HSZ 403

Grain boundary modifications in hot-deformed Nd-Fe-B permanent magnets by low melting eutectics — •Simon Sawatzki[1], Almut Dirks[1], Florian Esdar[1], Bianca Frincu[1], Konrad Löwe[1], and Oliver Gutfleisch[1,2] — [1]TU Darmstadt, Materialwissenschaft, Alarich-Weiß-Str. 16, 64287 Darmstadt, Germany — [2]IWKS Hanau, Fraunhofer-Projektgruppe für Wertstoffkreisläufe und Ressourcenstrategie , 63457 Hanau, Germany

The grain boundary diffusion process (GBDP) drastically reduces the heavy rare earth Dy in sintered Nd-Fe-B magnets without losing much in remanent magnetization [1]. Here Nd-Fe-B melt-spun ribbons with optimized composition for hot workability have been hot-compacted together with low melting DyCu, DyNiAl, NdCu and NdAl powders to enhance coercivity. Annealing at 600°C leads to an interdiffusion of Dy and Nd at the interfaces between the Nd-Fe-B flakes and the Dy-rich phase that was visualized by high-resolution secondary electron microscopy (HR-SEM). This interdiffusion modifies the grain boundary phase and thus further enhances coercivity without decreasing remanence. The higher coercivity for DyCu compared to DyNiAl was attributed to the lower melting point obtained by differential scanning calorimetry (DSC). For NdCu and NdAl annealing was found to be ineffective. Following this, hot-compacted magnets have been die-upset in order to prepare textured composite magnets.

[1] Park et al. Proc. 16th Int. Workshop on RE Magnets and their Applications (Sendai, Japan) (2000) p.257

MA 52.5 Fri 10:30 HSZ 403

High-throughput search for new rare-earth lean permanent magnets — •Dagmar Goll, Ralf Löffler, Johannes Herbst, Roman Karimi, and Gerhard Schneider — Hochschule Aalen, Institut für Materialforschung, Beethovenstraße 1, 73430 Aalen

Fe-Nd-B magnets with their extremely high performance have severe disadvantages in cost-efficiency due to their rare earth (RE) content and lifetime at $T > 200°$C. The demand for novel hard magnetic phases with better available RE metals, reduced RE content or RE free therefore is tremendous. The chances for the existence of such materials still exist due to the large number of so far unexplored alloy systems. To scan quickly through higher component systems we have developed suitable high-throughput approaches which are based on heterogeneous non-equilibrium states, so that one sample may be sufficient to cover the most relevant part of a phase diagram [1]. The efficiency of the high-throughput method is first demonstrated for the well-known systems Co-Sm and Fe-Nd-B. To identify the magnetic phases and analyze their intrinsic material parameters (anisotropy constant K_1, saturation polarization J_s, Curie temperature T_C) a combination of optical microscopy, Kerr microscopy and energy dispersive X-ray analysis in a scanning electron microscope is used. This allows to estimate K_1 and J_s from domain size and domain contrast. The high-throughput method is second demonstrated for discovered new hard magnetic phases based on Fe-Ce-X (X: additive) to estimate their potential concerning industrial relevance (*supported by BMBF*). [1] D. Goll, R. Löffler, J. Herbst, R. Karimi, G. Schneider, J. Phys.: Cond. Matter 26 (2014) in press.

MA 52.6 Fri 10:45 HSZ 403

Designing superhardmagnets from first principles — •José A. Flores Livas, S. Sharma, K. Dewhurst, and E. K. U. Gross — Max-Planck-Institut Für Mikrostrukturphysik, Halle (Saale), Germany

High-throughput computational materials design is currently exploited in many fields of materials science, such as photovoltaic, battery technologies, energy saving devices, thermoelectric materials and even more recently to search for new topological insulators. By combining advanced DFT electronic-structure methods with intelligent data mining, database construction, crystal prediction methods and exploiting the power of current supercomputer architectures; scientists generate, manage and analyse enormous data repositories for the discovery of novel materials. Following this idea we endeavour in the search for new superhardmagnets, for which we propose a simple and a robust descriptor in order to evaluate possible candidates. In this talk, I will present: i) Brief description of our research methodology (algorithm and computational search). ii) Benchmarking of our current implementations and principal drawbacks of our methodology. iii) Latest results and efforts in order to find new superhardmagnets containing less rare-earth metals.

MA 52.7 Fri 11:00 HSZ 403

The influence of the domain wall sub-structures on magnetization reversal — •Sukhvinder Singh, Haibin Gao, and Uwe

Hartmann — Institute of Experimental Physics, Saarland University, P O. Box 151150, D66041, Saarbrücken, Germany

Sub-structures (Bloch Lines, cross-tie wall components, vortex-antivortex pairs) of domain walls significantly affect the magnetic properties of patterned materials [1, 2]. In this study we have investigated their influence towards the magnetization reversal of microstructured thin films. The patterns were prepared in square and rectangular shapes of various aspect ratios by means of e-beam lithography. Different thicknesses of Permalloy (Ni81Fe19) in the range of 20 nm to 150 nm were prepared by sputtering. An in-plane static magnetic field was applied to move the domain walls. The changes in the sub-structures of domain walls were observed by Magnetic Force Microscopy. The results were compared with micromagnetic simulations and the contributions of the different magnetic energies were investigated.

[1] C. Y. Kuo et al. J. Magn. Magn. Mater. 310, e672 (2007)
[2] C. Zinoni et al. Phys. Rev. Lett. 107, 207204 (2011)

MA 52.8 Fri 11:15 HSZ 403

The giant magnetoimpedance of iron single crystals — Matthäus Langosch, Thomas Karwoth, •Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P. O. Box 151150, D66041, Saarbrücken, Germany

Extended magnetoimpedance measurements on iron single crystals with <100> growth direction were performed at room temperature as a function of the applied longitudinal magnetic field and of the applied current frequency. In the chosen frequency regime, it is found that there is a maximum magnetoimpedance ratio of more than 150% under the chosen experimental conditions. To investigate the origin of the effect, magneto-optic Kerr effect (MOKE) microscopy experiments were performed to study the contribution of the magnetic domain structures and domain wall movement. The investigations show that, apart from the well-known Landau structures and the sheath-core one, mixed magnetic domain structures are existing as well. A detailed analysis of the MOKE images indicates that the structures have a helical shape. In addition, calculations based on the standard skin effect formalism permit the determination of the magnitude and the phase of the effective circumferential permeability. The resulting values of the effective circumferential permeability make it possible to distinguish between different regimes dependent on the external longitudinal magnetic field and the magnitude of the applied current.

MA 53: Spin Structures at Surfaces and in thin films II

Time: Friday 9:30–12:00 Location: BEY 118

MA 53.1 Fri 9:30 BEY 118

Co nanodot arrays grown on a ferromagnetic $GdAu_2$ template: substrate/nanodot antiferromagnetic exchange coupling — •Laura Fernandez[1], Maria Blanco Rey[1,2], Maxim Ilyn[3], Lucia Vitali[4], Alex Correa[1], Philippe Ohresser[5], Enrique Ortega[1,2,3,4], Andrés Ayuela[1,3], and Frederik Schiller[1,3] — [1]Donostia International Physics Center, San Sebastian, Spain — [2]Universidad del Pais Vasco (UPV/EHU), San Sebastian, Spain — [3]Centro de Física de Materiales, San Sebastian, Spain — [4]Ikerbasque, Bilbao, Spain — [5]Soleil, Saint-Aubin, France

Controlling and manipulating exchange coupling and anisotropy in patterned magnetic nanostructures is the key for developing advanced magnetic storage and spintronic devices. Here we search the magnetic interaction between a Co nanodot array and its supporting ferromagnetic $GdAu_2$ nanotemplate. X-ray magnetic circular dichroism measurements reveal strong antiferromagnetic coupling across the Co/$GdAu_2$ interface, which is corroborated by full-potential linearized augmented plane wave calculations. These studies find that the anisotropy of the Co nanodots is profoundly modified by the influence of the $GdAu_2$ nanotemplate that induces large anisotropy values. In clear contrast with non-magnetic Au substrates, $GdAu_2$ triggers the early switch in the anisotropy direction from out-of-plane in monolayer-thick Co, to in-plane, in bilayer Co films.

MA 53.2 Fri 9:45 BEY 118

Tuning of the magnetic properties of Co adatoms on Graphene through interaction with a metal substrate — •Alberto Cavallin[1,2], Fabio Donati[1], Luca Gragnaniello[1], Fabian D. Natterer[1], François Patthey[1], Quentin Dubout[1], Jan Dreiser[1,3], Cinthia Piamonteze[3], Frithjof Nolting[3], Stefano Rusponi[1], and Harald Brune[1] — [1]Institute of Condensed Matter Physics (ICMP), École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland — [2]present address: Max-Planck-Institut für Mikrostrukturphysik, Halle (Saale), Germany — [3]Swiss Light Source (SLS), Paul Scherrer Institut (PSI), Villigen, Switzerland.

The magnetic properties of adatoms on graphene (G) are extremely relevant in view of potential applications in spintronics. Nowadays large efforts are devoted to predict the physics of long range interactions between magnetic moments localized on Co and Fe adatoms and mediated by the graphene conduction electrons.[1]

The magnetic ground state and anisotropy of Co adatoms on G are however much debated at present.[2] Here, we show a strong dependence of these properties on the metal substrate on which G is grown. A state of the art investigation based on XAS, XMCD, STM, STS and multiplet calculations reveals large spin and orbital moments, and an out-of-plane easy axis for Co/G/Ru(0001), while it shows comparatively weak magnetic moments and anisotropy for Co/G/Ir(111).

[1] S. R. Power and M. S. Ferreira, Crystals, **3**, 49 (2013).
[2] F. Donati, Q. Dubout *et al.*, Phys. Rev. Lett. **111**, (2013), and references therein.

MA 53.3 Fri 10:00 BEY 118

Unexpected behaviour of the magnetocrystalline anisotropy of adatoms as a function of the spin orbit coupling — •Ondřej Šipr[1], Sven Bornemann[2], Sergey Mankovsky[2], Hubert Ebert[2], and Ján Minár[2] — [1]Institute of Physics of the ASCR, Praha, Czech Republic — [2]Universität München, München, Germany

The origin of magneto-crystalline anisotropy in various 3D solids, in 2D ultra-thin films, as well as in 0D magnetic clusters, was discussed in the literature by many authors who demonstrated that for uniaxial systems its dependence on the strength of the spin orbit coupling (SOC) is quadratic. This property is the result of small magnitude of SOC energy when compared to the electron band width of such systems, which allows to account for its contribution within the second order perturbation theory.

However, the situation can be different in the case of single atoms deposited on a surface. We demonstrate by the ab-initio electronic structure calculations that for 3d transition metal adatoms on Au(111) the dependence of the magneto-crystalline anisotropy energy on the SOC becomes quite complicated and it is rather linear than quadratic for realistic SOC values. This feature can be attributed to the very narrow electronic bands associated with the adatoms being comparable to the SOC-induced changes upon the rotation of the magnetization direction.

MA 53.4 Fri 10:15 BEY 118

Magnetic hardening induced by nonmagnetic organic molecules — •Martin Callsen, Vasile Caciuc, Nikolai Kiselev, Nicolae Atodiresei, and Stefan Blügel — Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

One target of molecular spintronics is to design new, molecule based magnetic materials with predefined magnetic and electronic properties for spintronic applications. By means of *ab initio* calculations in the framework of density functional theory we revealed that the adsorption of a nonmagnetic π-conjugated organic molecule on a ferromagnetic surface locally increases the strength of the magnetic exchange interaction between the magnetic atoms binding directly to the molecule [1]. In particular, we investigated the prototypical, biplanar [2,2]paracyclophane molecule adsorbed on the Fe/W(110) surface. The observed magnetic hardening effect leads to the creation of a local molecule mediated magnetic unit with a stable magnetization direction and an enhanced barrier for the magnetization switching as compared to the clean surface. In addition, this hybrid organic-ferromagnetic system exhibits a spin-filter functionality with sharp spin-split molecular-like electronic features at the molecular site.

[1] M. Callsen *et al.*, Phys. Rev. Lett. **111**, 106805 (2013)

MA 53.5 Fri 10:30 BEY 118

Electric-field induced magnetic anisotropy on the atomic scale — •Andreas Sonntag, Jan Hermenau, Anika Schlenhoff, Johannes Friedlein, Stefan Krause, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Germany

One of the challenges in data storage applications is the control of magnetic anisotropy: To stabilize a magnetic bit against thermal magnetization reversal a large anisotropy is needed, while a low anisotropy is desired when writing information. A device employing electric fields to actively reduce the magnetic anisotropy during writing could benefit from smaller power consumption compared to conventional devices.

In our experiments we investigate the impact of an electric field onto the anisotropy of individual atomic-scale magnets. The superparamagnetic switching of uniaxial Fe magnets on W(110) [1] is studied using spin-polarized scanning tunneling microscopy (SP-STM). Electric fields up to 6 GV/m are applied at very low tunnel current, thereby excluding current induced effects. The experiments show that the electric field E can be used to increase or decrease the switching rate, depending on the sign of E. This is attributed to an electric-field induced anisotropy that favors in-plane magnetization for $E < 0$ and out-of-plane magnetization for $E > 0$. The interpretation of this concept is verified by changing from an in-plane to an out-of-plane system.

Our experiments demonstrate magnetic manipulation without exploiting spin or charge currents, thereby opening the pathway towards electric-field based spintronic applications on the atomic scale.

[1] S. Krause *et al.*, Phys. Rev. Lett. **103**, 127202 (2009).

MA 53.6 Fri 10:45 BEY 118

Spin states of single holmium adatoms with exceptionally long lifetimes — Toshio Miyamachi, Tobias Schuh, •Tobias Märkl, Timofey Balashov, Christopher Bresch, Alexander Stöhr, and Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Straße 1, 76131 Karlsruhe, Germany

In order to use single atomic spins in data storage and processing, stable spin states are crucial. Generally, transition metal atoms on metallic surfaces or thin insulating films show short spin lifetimes of less than a microsecond due to a strong hybridization between substrate electrons and the 3d-orbitals of the atom.

Here, we report on a series of experiments to investigate spin states of Ho atoms on a Pt(111) surface with STM. In this approach we combined the characteristics of a rare earth atom with the symmetries of the adsorption site to significantly decouple the 4f orbitals from the substrate, resulting in lifetimes up to several minutes. [1]

[1] T. Miyamachi et al., Nature 503, 242-246 (2013)

MA 53.7 Fri 11:00 BEY 118

Reduced dimensionality induced magnetic stripe phase in Fe nanoislands — •Soo-hyon Phark[1], Jeison Fischer[1,2], Marco Corbetta[1], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Universidade Federal de Santa Catarina , Florianópolis, Brazil

Low-dimensionality in itinerant magnetic materials often leads to magnetic ground states of non-collinear magnetic order [1], such as spin helices and skyrmions. Recent theoretical works predicted that competing exchange interactions induce a spin helix in bcc Fe(110) monolayers [2]. Here we report an observation of a magnetic stripe phase with a period of 1.28 nm in bilayer Fe nanoislands on Cu(111) [3]. In-field spin-polarized scanning tunneling microscopy and spectroscopy reveal that the stripe phase originates from a helical spin ordering. Together with theoretical insights [2], our finding provides compelling experimental evidence that a non-collinear magnetic ordering can be stabilized in a system where a long-range antiferromagnetic exchange interaction is enhanced due to a reduced dimensionality.

[1] S. Mühlbauer, B. Binz, F. Jonietz, C. Pfleiderer, A. Rosch, A. Neubauer, R. Georgii, P. Böni, Science 323, 915 (2009). [2] K. Nakamura, N. Mizuno, T. Akiyama, T. Ito, A. Freeman, J. Appl. Phys. 99, 08N501 (2006). [3] A. Biedermann, W. Rupp, M. Schmid, P. Varga, Phys. Rev. B 73, 165418 (2006).

MA 53.8 Fri 11:15 BEY 118

Superconducting scanning tunneling microscope tips as probes for absolute spin-polarization — •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

Spin-polarized tunneling pioneered by Robert Meservey and Paul Tedrow has become an essential field of study and opened up the way for many applications [1]. We transfer the concept of superconducting detector electrodes commonly used in standard thin film sandwich junctions to scanning tunneling microscopy (STM) to locally probe absolute spin-polarization. We have studied superconducting vanadium STM tips on normal conducting samples in high magnetic fields at 10 mK. The superconducting properties of those tips are determined by the confinement due to the specific tip geometry. Superconducting STM tips have been employed as local probe for the absolute spin-polarization of Co nanoislands on Cu(111). Our results qualitatively agree with experiments carried out by SP-STM [2] but the absolute values of the measured spin-polarization allows for further analysis of the orbital wave functions involved in the tunneling process.

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MA 53.9 Fri 11:30 BEY 118

Interplay of orbital-dependent tunneling and spin-polarization in STM/STS — Gábor Mándi, Mátyás Seress, and •Krisztián Palotás — Budapest University of Technology and Economics, Department of Theoretical Physics, Budafoki út 8., H-1111 Budapest, Hungary

Scanning tunneling microscopy (STM) images of magnetic surfaces can show contrast changes depending on the bias voltage or tip magnetization orientation [1]. We investigate the interplay of orbital-dependent tunneling [2] and spin-polarization effects on constant-current STM images of the Fe(110) surface. We find that the atomic contrast inversion is sensitive to the spin-polarization and the orbital character of the STM tip [3]. Taking a moiré-patterned Co/Ag(111) surface [4], we calculate differential conductance tunneling spectra (STS), and the results demonstrate the sensitivity of the spectra on the spin-polarization and the orbital composition of the tip.

The simulations are performed using a three-dimensional Wentzel-Kramers-Brillouin tunneling model based on ab initio electronic structure data [5].

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[1] K. Palotás, Phys. Rev. B 87, 024417 (2013).
[2] K. Palotás et al., Phys. Rev. B 86, 235415 (2012).
[3] G. Mándi and K. Palotás, arXiv:1309.4696 (2013).
[4] T. G. Gopakumar et al., Chem. Phys. Lett. 484, 59 (2009).
[5] K. Palotás et al., Front. Phys., DOI: 10.1007/s11467-013-0354-4 (2013).

MA 53.10 Fri 11:45 BEY 118

Enhanced atomic-scale spin contrast due to spin friction — •Safia Ouazi, André Kubetzka, Kirsten von Bergmann, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

We report that atomic-scale magnetic contrast can be enhanced by one order of magnitude when a magnetic adatom is controllably trapped between a scanning tunneling microscope tip and a magnetic substrate during scanning. As model system, we study the $(\sqrt{3} \times \sqrt{3})R30°$ magnetic superstructure of a monolayer Fe on Re(0001), with low-temperature spin-polarized scanning tunneling microscope measurements (SP-STM). The observed in-plane Néel ordered state has a magnetic unit cell of three atoms. We obtain magnetic atom manipulation images from the tunneling regime to almost contact regime by systematically varying the gap resistance. This parameter determines the tip-sample distance and tunes the magnetic interactions between the tip, sample and the magnetic adatom. At intermediate gap resistance, we observe that the motion of the manipulated atom depends on the spin alignment of the magnetic layer and consider this a manifestation of spin friction, as in [1]. We discuss the role of tip-sample distance for the observation of the magnetic structure of the sample and the mechanism for the boost of magnetic corrugation.

[1] Wolter, B. et al, Phys. Rev. Lett. 109, 116102 (2012)

MA 54: Graphene: Bi- and multi-layers (with DY/DS/HL/O/TT)

Time: Friday 9:30–11:00 Location: POT 081

MA 54.1 Fri 9:30 POT 081

Atomistic simulations of dislocations in bilayer graphene — •Konstantin Weber[1], Christian Dolle[2], Florian Niekiel[2], Benjamin Butz[2], Erdmann Spieker[2], and Bernd Meyer[1] — [1]Interdisciplinary Center for Molecular Materials and Computer-Chemistry-Center, FAU Erlangen-Nürnberg — [2]Center for Nanoanalysis and Electron Microscopy, FAU Erlangen-Nürnberg

The atomic structure and the properties of basal-plane dislocations in bilayer graphene, the thinnest imaginable crystal that can host such 1D defects, has been investigated by atomistic simulations based on the registry-dependent potential of Kolmogorov and Crespi [1] and the classical AIREBO potential.
Our calculations show that the dislocations lead to a pronounced buckling of the graphene bilayers in order to release strain energy, leading to a complete delocalization of the residual compressive/tensile strain in the two graphene sheets [2]. Furthermore, the absence of a stacking-fault energy, a unique peculiarity of bilayer graphene, gives rise to a splitting of the dislocations into equidistant partials with alternating Burgers vectors [2]. Thus, dislocations in bilayer graphene show a distinctly different behavior than corresponding dislocations in graphite or other 3D crystals.

[1] A. Kolmogorov, V. Crespi, *Phys. Rev. B* **71**, 235415 (2005).
[2] B.Butz, C. Dolle, F. Niekiel, K. Weber, D. Waldmann, H.B. Weber, B. Meyer, E. Spieker, *Nature*, (2013) (accepted for publication).

MA 54.2 Fri 9:45 POT 081

Study of the magnetoresistance of biased graphene bilayers — •Dmitri Smirnov[1], Galina Y. Vasileva[1,2], Yurij B. Vasilyev[2], Pavel S. Alekseev[2], Yurij L. Ivanov[2], Hennrik Schmidt[1], Alexander W. Heine[1], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover — [2]Ioffe Physical Technical Institute, Russian Academy of Sciences, St. Petersburg

We demonstrate magnetotransport behaviour of bilayer graphene. In contrast to monolayer graphene, bilayer has a parabolic band structure with a zero band gap, which can be opened by applying an electrical field perpendicular to the samples [1]. One of the consequences of such a band structure is the coexistence of two different types of charge carriers with the Fermi energy placed near the charge neutrality point.

Several bilayer graphene samples with different electrical properties (charge neutrality point, mobility) have been investigated. A positive and negative magnetoresistance is observed for electrons and holes. We can show that that the positive magnetotransport can be described well with a two carrier Drude model which allows us a new approach to probe parameters of electrons and holes separately.

[1] McCann, E., and V. Fal'ko Phys. Rev. Lett. 96, 086805 (2006)

MA 54.3 Fri 10:00 POT 081

Transport in Dual Gated Encapsulated Bilayer Graphene — •Jonas Hesselmann[1], Stephan Engels[1,2], Bernat Terrés[1,2], Kenji Watanabe[3], Takashi Taniguchi[3], and Christoph Stampfer[1,2] — [1]JARA-FIT and II. Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [3]National Institute for Materials Science, 1-1 Namiki, Tsukuba, 305-0044, Japan

Bilayer graphene (BLG) is a promising material which combines superior electronic properties like high charge carrier mobilities with the possibility of opening a band gap. The band gap can be induced by applying a perpendicular electric field resulting in a gap in the order of a few 10 meV. This makes BLG a possible candidate for future nanoelectronic applications. Here, we present the fabrication and low temperature (T=2K) transport measurements of dual gated BLG which is encapsulated in hexagonal boron nitride serving as an atomically flat gate dielectric. We show that the investigated devices exhibit mobilities of up to 80.000 cm^2/Vs. Quantum Hall effect measurements show a distinct sequence of Hall plateaus together with a full symmetry breaking of the eightfold degenerate zero Landau level. By temperature dependent measurements we investigate the energy gap opening as function of a perpendicular electric field. We find that the transport via localized states at low temperatures exhibits a strong asymmetric behavior with respect to the sign of the applied electric field while the temperature activated transport is fully symmetric.

MA 54.4 Fri 10:15 POT 081

An emergent momentum scale and low energy theory for the graphene twist bilayer. — •Sam Shallcross, Nicolas Ray, Dominik Weckbecker, and Oleg Pankratov — Theoretische Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7B2, 91058 Erlangen

We identify an angle dependent *momentum scale* as the fundamental property of a bilayer composed of mutually rotated graphene layers [1]. This leads to (i) a numerical method that increases, for the twist bilayer, the efficiency of the standard tight-binding method by a factor of $\approx 10^3$, at no loss of accuracy, and (ii) a low energy theory that can be deployed, without distinction, for both the low angle regime and the large angle regime. In the low angle regime this leads to a theory that is close to that of Bistritzer *et al.* [2], but differs in the choice of momentum scale. In the large angle this approach yields electronic versions of the Hamiltonians first derived on symmetry grounds by Mele [3]. We use these low energy approaches to give an overview of the $T = 0$ electronic properties of the twist bilayer system, with a particular focus on the localization of electrons, mixing of single layer graphene states by the interaction, and low energy density of states features.
[1] S. Shallcross, S. Sharma, and O. Pankratov, *Phys. Rev. B* **87**, 245403, 2012.
[2] R. Bistritzer and A. H. MacDonald. *Proc. Natl Acad. Sci.*, **108:12233**, 2010.
[3] E. J. Mele. *Journal of Physics D Applied Physics*, **45:154004**, 2012.

MA 54.5 Fri 10:30 POT 081

RKKY interaction in the AB stacked graphene bilayer: interstitial impurities and a diverging propagator. — •Nicolas Klier, Sam Shallcross, and Oleg Pankratov — Theoretische Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7B2, 91058 Erlangen

The interaction between spin polarised impurities in graphene displays a number of novel features that arise both from the valley degree of freedom that graphene possesses, as well as the linearly vanishing density of states at the Dirac point [1,2]. Multilayer graphene systems offer both the possibility of realistic interstitial (i.e., interlayer) impurities, as well as novel electronic features. In particular, the Bernal stacked (AB) bilayer exhibits low energy (chiral) bands as well as high energy bonding and anti-bonding bands. We demonstrate that at the bonding to anti-bonding *gap edge* there is an logarithmic divergence $\log(E - E_g)$ in the propagator on one sublattice, with E the energy and E_g the energy of the bonding to anti-bonding gap (0.38 eV). This leads to a number of dramatic consequences for the RKKY interaction, most notably: (i) a $R^{-5/2}$ impurity interaction at the gap edge, and, (ii) for interstitial impurities a discontinuous change in the Fermi surface spanning vector that drives the RKKY at the gap edge. We further derive the finite temperature behaviour of this system on the basis of finite temperature perturbation theory.
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[2] F.Parhizgar, and M.Sherafati, and R.Asgari, and S.Satpathy, Phys. Rev. B 87, 165429, 2013.

MA 54.6 Fri 10:45 POT 081

Conductivity of two-dimensional charge carriers with non-parabolic dispersion — Bretislav Sopik[1], Janik Kailasvuori[2,3], and •Maxim Trushin[4] — [1]Central European Institute of Technology, Masaryk University, Kamenice 735, 62500 Brno, Czech Republic — [2]International Institute of Physics, Universidade Federal do Rio Grande do Norte, 59078-400 Natal-RN, Brazil — [3]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [4]University of Konstanz, Fachbereich Physik, M703 D-78457 Konstanz

We investigate the conductivity of two-dimensional charge carriers with the non-parabolic dispersion k^N with N being an arbitrary natural number assuming the delta-shaped scattering potential as a major source of disorder. We employ the exact solution of the Lippmann-Schwinger equation to derive an analytical Boltzmann conductivity formula valid for an arbitrary scattering potential strength. We proceed further with a numerical study based on the finite size Kubo

formula which assesses the applicability range of our analytical model. We find that for any $N > 1$, the conductivity demonstrates a linear dependence on the carrier concentration in the limit of a strong scattering potential strength. This finding agrees with the conductivity measurements performed recently on chirally stacked multilayer graphene [1] where the lowest two bands are non-parabolic and the adsorbed hydrocarbons might act as strong short-range scatterers.

[1] L. Zhang, Y. Zhang, J. Camacho, M. Khodas I. Zaliznyak, Nature Physics **7**, 953-957 (2011).

MA 55: Poster II

Magnetic Heuslers / Multiferroics / Spin Transport Phenomena and Spintronics/ Spin- and Magnetization Dynamics / Spin Structures and Phase Transitions / Magnetic Thin Films / Electronic Structure (Theory) / Topological Insulators

Time: Friday 10:30–13:30 Location: P2

MA 55.1 Fri 10:30 P2

Ferroelectric and magnetic properties of doped $BiFeO_3$ and $BiFeO_3/BaTiO_3$ composite and multilayer thin films — •Peter Schwinkendorf[1], Michael Lorenz[1], Vera Lazenka[2], Holger Hochmuth[1], and Marius Grundmann[1] — [1]Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig — [2]Institute for Nanoscale Physics and Chemistry, KU Leuven

$BiFeO_3$ is to date the most widely studied single phase material concerning potential application as multiferroic in the development of upcoming new computer memory technologies. This is due to its unique combination of room temperature ferroelectricity (polarization values of up to $60\,C\,cm^{-2}$) and ferromagnetism [1].

However, single phase $BiFeO_3$ films often suffer from high leakage currents. In order to overcome this problem and possibly modify the basic ferroelectric and magnetic properties we show here multiferroic composite thin films and multilayers consisting of $BiFeO_3$ and $BaTiO_3$ as well as doping of $BiFeO_3$ films with rare earth ions [2].

As expected, an increasing $BaTiO_3$ content in the samples decreases the leakage current but maintains a high ferroelectric polarization. We furthermore found that multilayers exhibit considerably enhanced magnetic properties compared to single phase films. The same is observed for Gd-doped films while La-doping causes smoothening of the film surface [2]. Magnetoelectric coupling in the composites was investigated via two different methods.

[1] J. Wang, Science 299, 1719 (2003)
[2] V. Lazenka, J. Phys. D: Appl. Phys. 46 175006 (2013)

MA 55.2 Fri 10:30 P2

Magnon Bose Einstein Condensate moving in real space — •Patryk Nowik-Boltyk, Oleksandr Dzyapko, Vladislav E. Demidov, and Sergej O. Demokritov — Institute of Applied Physics, University of Muenster, Muenster, Germany

Magnon Bose-Einstein condensation, created by microwave pumping in Yttrium-Iron-Garnet films, is a spectacular room-temperature macroscopic quantum phenomenon, which is under extended investigation since recently [1]. Temporal [2] and spatial [3] coherence of the condensate have extensively been studied in the past 5 years. As a mBEC is located at the ground state of the magnon system its group velocity is zero, therefore the condensate is not moving in real space and occupies the same area are for a long time if kept in flow equilibrium. We demonstrate a way to create a moving condensate by applying a pulsed magnetic field localized in real space. As a result of the pulsed field the condensate gains a group velocity that is determined by the amplitude of the localized magnetic field. The space, time and frequency dependent magnon density has been determined using a space, time and frequency resolved Brillouin light scattering technique. [1] S.O. Demokritov et al. Nature 443, 430 (2006) [2] V.E. Demidov et al. Phys. Rev. Lett. 100, 047205 (2008) [3] P. Nowik-Boltyk et al. Nature Sci. Rep. 2, 482 (2012)

MA 55.3 Fri 10:30 P2

Long-term magnetic stability of single atoms: a group-theoretical viewpoint — •Timofey Balashov, Christopher Bresch, and Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

The recent observation of extremely long lifetimes in single Holmium atoms on Pt(111) [1] can be explained by a careful consideration of the inherent symmetries of the system; namely, the rotation symmetry of the adsorption site, the total angular momentum symmetry of the atom and the time reversal symmetry of the whole system. Here, we describe the model in more detail and demonstrate its robustness against perturbations. We also apply this model to other rare earths to identify promising systems for future research.

[1] T. Miyamachi et al, *Nature* **503**, 242 (2013)

MA 55.4 Fri 10:30 P2

Material and bias dependence of the tunnel magnetoresistance and spin-transfer torque in magnetic 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 ferromagnetic 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 [1]. The transport properties are obtained using a non-equilibrium Green's function method. The FeCo alloys are described by the coherent potential approximation (CPA) including vertex corrections [2].

The disorder scattering, which is included by the CPA description, leads to diffusive currents. These lead to a drop in the TMR at zero bias from large values for the pure materials to around 2000% at finite concentrations. At a large bias we find that the TMR decreases with the Co concentration as a result of the band filling. Likewise, the TMR decreases much faster with increasing bias voltage for pure Co leads than for smaller Co concentrations. The in-plane and out-of-plane STT show linear and quadratic voltage dependence at small bias for all concentrations. The linear slope of the in-plane STT is independent of the concentration. At large bias voltages, we find strong deviations from this dependence for high Co concentrations.

[1] C. Franz et. al, Phys. Rev. B 88, 094421 (2013)
[2] C. Franz et. al, J. Phys.: Condens. Matter 25, 425301 (2013)

MA 55.5 Fri 10:30 P2

Evaluating the Gilbert damping in individual $Co_2Mn_{0.6}Fe_{0.4}Si$ microstructures via parametric amplification — •T. Sebastian[1,2], T. Brächer[1,3], P. Pirro[1], Y. Kawada[4], H. Naganuma[4], A.A. Serga[1], M. Oogane[4], Y. Ando[4], and B. Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [3]Graduate School Materials Science in Mainz, 67663 Kaiserslautern, Germany — [4]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Sendai 980-8579, Japan

Recent experiments on spin dynamics in microstructures made of the Heusler compound $Co_2Mn_{0.6}Fe_{0.4}Si$ (CMFS) yielded promising results in the linear and nonlinear regime [1,2]. These results were attributed to the low Gilbert damping that was observed with standard ferromagnetic resonance (FMR) technique on homogeneous thin films. However, a quantitative analysis of the damping in CMFS microstructures is still lacking. We present an alternative method to evaluate the damping in individual CMFS microstructures using parametric amplification [3] and show that the low damping is preserved on the microscale.

We acknowledge support by 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).
[2] T. Sebastian, et al., Phys. Rev. Lett. **110**, 067201 (2013).
[3] H. Ulrichs, et al., Phys. Rev. B **84**, 094401 (2011).

MA 55.6 Fri 10:30 P2

Investigation of Pt growth on Yttrium Iron Garnet — •Sabine Pütter[1], Stephan Geprägs[2], and Rudolf Gross[2] — [1]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstatation at MLZ, 85747 Garching, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

For spintronics, heterostructures of ferromagnetic insulators and non-magnetic conductors are very interesting as e.g. the spin Seebeck or the spin Hall effect can be studied. Pt/Yttrium Iron Garnet ($Y_3Fe_5O_{12}$,YIG) is currently in focus [1]. Only recently, it has been found that the quality of the Pt/YIG interface is crucial [2-4].

We performed a detailed growth study of Pt on YIG single crystals. The samples have been studied in-situ by Auger-Electron-Spectroscopy and Reflection High/Low Energy Electron Diffraction and ex-situ by X-ray reflectivity. Pt was thermally evaporated utilizing the JCNS molecular beam epitaxy system which is also open to users in the framework of neutron experiments performed at the MLZ (www.mlz-garching.de).

[1] Y. Sun et al. Phys. Rev. Lett. 111, 106601 (2013) and references therein, H. Nakayama et al., Phys. Rev. Lett. 110, 206601 (2013), M. Weiler et al., Phys. Rev. Lett. 108, 106602 (2012).
[2] F. D. Czeschka et al., Phys. Rev. Lett. 107, 046601 (2011)
[3] M. B. Jungfleisch et al., Appl. Phys. Lett. 103, 022411 (2013)
[4] Z. Qiu et al. Appl. Phys. Lett. 103, 092404 (2013)

MA 55.7 Fri 10:30 P2

Pure spin current-induced domain wall motion probed by localized spin signal detection — Nils Motzko[1], Björn Burkhardt[1], Robert Reeve[1], Alexander Pfeiffer[1], •Mathias Kläui[1], Piotr Laczkowski[2], Williams Savero Torres[2], Laurent Vila[2], and Jean-Philippe Attane[3] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz, 55099 Mainz, Germany — [2]INAC, CEA Grenoble, 17 av. des Martyrs, 38054 Grenoble, France — [3]INAC, CEA Grenoble, 17 av. des Martyrs, 38054 Grenoble, France and Universite Jospeh Fourier, BP 53, 38041 Grenoble, France

We demonstrate the displacement of domain walls by pure diffusive spin currents, using a non-local spin valve geometry without any applied external fields. We detect the position of the domain wall by non-local spin valve measurements at both sides of the spin conduit, thereby detecting the domain wall position that is moving across the area below the spin conduit when a spin current is applied. We find that it is possible to displace a transverse wall without any external field with a spin current density of
$6 \cdot 10^9 A/m^2$, and a charge current density of $4 \cdot 10^{11} A/m^2$, which is lower than what is required for conventional spin-polarized charge current-induced domain wall motion. The spin polarisation of permalloy was calculated to 31 % and the spin diffusion length to 349 nm. The observed efficiency of 10^{-12}T m^2/A is the highest ever obtained for domain walls in permalloy demonstrating that this method is advantageous for low power domain wall manipulation.

MA 55.8 Fri 10:30 P2

Enhancement of spin currents by three-magnon splitting — Oleksandr Dzyapko[1], Hidekazu Kurebayashi[2], Vladislav E. Demidov[1], •Michael Evelt[1], and Sergej O. Demokritov[1] — [1]Institute for Applied Physics, University of Muenster, Germany — [2]Cavendish Laboratory, University of Cambridge, United Kingdom

The effect of spin-pumping offers a perfect possibility to generate pure spin currents in a layered system of ferromagnetic and normal metals by excitation of spin precession in the ferromagnet. Vice versa, detecting the spin current using the inverse spin-Hall effect (ISHE) allows investigation of magnetic dynamics.
Here we report on the examination of the spin pumping in yttrium iron garnet (YIG)/Pt bilayers for different thickness of YIG. We show that the efficiency of the spin-current generation can be significantly enhanced by three-magnon splitting in YIG. This is only allowed for particular intervals of applied magnetic fields depending on the thickness of the ferromagnetic film (energy conservation). Our results show that for all samples with allowed three-magnon splitting an enhancement of the spin current generation is observed in a certain frequency region. The cut-off frequencies characterizing the region of the enhancement correlate perfectly with the theoretically predicted frequency for the latter process, confirming the experimental claims [1,2] that three-magnon splitting is responsible for the observed amplification.

[1] H. Kurebayashi, O. Dzyapko, et al, Nature Mater. 10, 660 (2011)
[2] O. Dzyapko, H. Kurebayashi, et al, Applied Physics Letters 102, 252409 (2013)

MA 55.9 Fri 10:30 P2

Absence of an induced magnetic moment in Pt on $Y_3Fe_5O_{12}$ — Stephan Geprägs[1], •Matthias Opel[1], Sibylle Meyer[1], Fabrice Wilhelm[2], Katharina Ollefs[2], Andrei Rogalev[2], Sebastian T.B. Goennenwein[1], and Rudolf Gross[1,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]European Synchrotron Radiation Facility (ESRF), Grenoble, France — [3]Physik-Department, TU München, Garching, Germany

The investigation of pure spin currents in ferromagnetic insulating $Y_3Fe_5O_{12}$ (YIG) is usually based on their conversion to charge currents in an adjacent metallic Pt layer via the inverse spin Hall effect. Recently, magnetotransport experiments in Pt/YIG heterostructures revealed a magnetoresistance (MR) effect in Pt which is interpreted controversially in terms of a novel spin-Hall MR [1] or a magnetic proximity MR [2]. To clarify this issue, we study the X-ray magnetic circular dichroism (XMCD) at the Pt $L_{2,3}$ edges in Pt/YIG [3]. Our data unambiguously show a negligible induced magnetic moment below (0.003 ± 0.001) Bohr magnetons per Pt atom, in contrast to [2]. This suggests that a magnetic proximity effect cannot be responsible for the observed MR in Pt/YIG. Our data instead are fully consistent with the spin-Hall MR interpretation. – This work was supported by the ESRF via HE-3784, the Deutsche Forschungsgemeinschaft (DFG) via SPP 1538, and the German Excellence Initiative via NIM.

[1] H. Nakayama *et al.*, Phys. Rev. Lett. **110**, 206601 (2013).
[2] Y.M. Lu *et al.*, Phys. Rev. Lett. **110**, 147207 (2013).
[3] S. Geprägs *et al.*, Appl. Phys. Lett. **101**, 262407 (2012).

MA 55.10 Fri 10:30 P2

Iron Garnet Thin Films for Spin Current-Based Experiments — •Francesco Della Coletta[1], Sibylle Meyer[1], Matthias Opel[1], Sebastian T. B. Goennenwein[1], Stephan Geprägs[1], and Rudolf Gross[1,2] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, Technische Universität München, 85748 Garching, Germany

The generation and detection of pure spin currents are in the focus of present research. In ferromagnetic insulator (FMI)/non-magnetic metal (NM) bilayers, the (inter)conversion of spin and charge currents via the (inverse) spin Hall effect in the NM leads to a spin Hall magnetoresistance (SMR), resulting from reflection or absorption of spin current at the interface. The effect manifests itself in the dependence of the electrical resistivity of the NM on the magnetization orientation of the FMI. Candidates for room-temperature FMI layers are iron garnet $A_3Fe_5O_{12}$ (AIG) thin films with $A = \mathrm{Y, Gd}$. Using pulsed laser deposition, we fabricated epitaxial AIG thin films on $Gd_3Ga_5O_{12}$ and $Y_3Al_5O_{12}$ substrates. From X-ray diffractometry, we do not detect any secondary phases. Furthermore, a high structural quality and a low mosaic spread is demonstrated. Using SQUID magnetometry, a ferrimagnetic hysteresis with a saturation magnetization close to the bulk value of $A_3Fe_5O_{12}$ ($A = \mathrm{Y, Gd}$) is observed at room-temperature. Additionally, in case of $A = \mathrm{Gd}$, a compensation temperature of around 290 K, where the remanent magnetization changes its sign, is detectable. — This work is supported by the DFG via SPP 1538.

MA 55.11 Fri 10:30 P2

Spin Seebeck effect induced by resistive Joule heating — M. Schreier[1], N. Roschewsky[1], E. Dobler[1], S. Meyer[1], •R. Roesslhuber[1], R. Gross[1,2], and S.T.B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Germany — [2]Physik-Department, TUM, Germany

The spin Seebeck effect can be observed by applying a thermal gradient on a ferromagnet/normal metal hybrid structure, thus creating a thermal nonequilibrium state at the interface. As a result a pure spin current perpendicular to the interface is induced and converted into a charge current in the normal metal via the inverse spin Hall effect. So far, the thermal gradient was applied either by clamping the sample between two thermal reservoirs or by using local laser beam heating. Both techniques require a dedicated setup. Here we present a new and simple technique [1] for the generation of the thermal gradient wherein the normal metal layer itself is used as a resistive heater enabling spin Seeback experiments in standard magneto-transport cryostats. We show that the spin Seebeck effect can be recovered from the raw data by simply adding the voltage signals recorded for positive and nega-

tive current polarity. We performed measurements as a function of the external magnetic field strength and its orientation and show that the effect scales linearly with the applied power, as expected for a thermal effect. Supported by the DFG via SPP 1538 "Spin Caloric Transport" (project GO 944/4-1) and the German Excellence Initiative via the Nanosystems Initiative Munich (NIM).
[1] Schreier *et al.*, arXiv:1309.6901, accepted for publication in APL

MA 55.12 Fri 10:30 P2

Co thickness and temperature dependent anomalous Nernst and Hall effect in Co/Pd multilayers — •Tristan Matalla-Wagner, Vedat Keskin, Daniel Meier, Jan-Michael Schmalhorst, Timo Kuschel, and Günter Reiss — Thin Films and Physics of Nanostructures, Bielefeld University, Germany

The anomalous Hall effect (AHE) describes a charge voltage generated by spin-orbit-scattering of electrons in solid states. This voltage depends on the applied electric current and on the magnetization in the investigated material. Due to the dependence on the magnetization the voltage describes a magnetization curve which is antisymmetric with respect to the external magnetic field. The same antisymmetric shape of the magnetization curve can be obtained for the anomalous Nernst effect (ANE). Here, the driving force is a temperature gradient instead of an electric current. Therefore, the conclusion could be, that the ANE is a thermally generated AHE.

In Co/Pd multilayers the AHE depends on the Co thickness and temperature [1]. In this work, the impact of varying these parameters on the AHE as well as ANE is studied. The different behavior of AHE and ANE is discussed in context of spin Seebeck effect investigations.

[1] Keskin *et al.*, Appl. Phys. Lett. **102**, 022416 (2013)

MA 55.13 Fri 10:30 P2

Spin-wave control by thermal gradients — •Thomas Langner, Marc Vogel, Vitaliy Vasyuchka, Andrii Chumak, Alexander Serga, Georg von Freymann, and Burkard Hillebrands — TU Kaiserslautern and Landesforschungszentrum OPTIMAS

Spin waves, excitations of the spin system in a ferromagnetic material, show a high potential to transport information in form of spin angular momentum. In order to code and process data with spin waves one has to provide suitable means of manipulation. Magnonic crystals, magnetic media with periodic variation of the magnetic properties, provide a possibility to create a spin wave filter in analogy to photonic crystal based filters for light. In this work we investigate possibilities to create laser induced magnonic crystals. 532 nm continuous-wave laser-light patterns are generated by a spatial light modulator and imaged onto a spin-wave waveguide. The optically heated areas have a different saturation magnetization influencing the spin-wave propagation. First we study transmission and reflection of spin waves through a single thermally induced barrier. We then increase the number of light fringes focused to investigate the formation of a magnonic crystal and its influence on spin-wave transport. Controlling the laser power, heating time and distance between the fringes provides us with full control of all magnonic crystal parameters without the need to fabricate several samples.

We acknowledge financial support by the Deutsche Forschungsgemeinschaft (DFG) within priority program 1538 (Spin Caloric Transport).

MA 55.14 Fri 10:30 P2

Large tunnel magneto-Seebeck effect in Co2FeSi Heusler compound — •Alexander Boehnke[1], Marvin Walter[2], Christian Sterwerf[1], Michael Czerner[3], Karsten Rott[1], Andy Thomas[1], Christian Heiliger[3], Markus Münzenberg[2], and Günter Reiss[1] — [1]Thin Films and Physics of Nanostructures, Bielefeld University, Germany — [2]I. Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [3]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany

Heusler compounds are promising candidates for magnetic tunnel junctions (MTJ) as their potential high spin polarization leads to high tunnel magnetoresistance (TMR) ratios. Recently the tunnel magneto-Seebeck effect (TMS), that occurs when a temperature gradient is applied to an MTJ, has gained much interest. Our measurements show that Heusler compounds can give a good thermoelectric readout contrast, which is beneficial for future applications in, e.g., green information technology.

We investigated $Co_2FeSi/MgO/Co_{70}Fe_{30}$ MTJs. Interestingly, the TMS ratio (96 %) is comparable to the TMR ratio (101 %). Similar effects were found for Al_2O_3 barrier MTJs, but both observations differ from CoFeB/MgO/CoFeB MTJs, where the TMS is much smaller than the TMR. This reveals a strong influence of the contributing transport bands on the TMS, basically different from the TMR. Further ab initio calculations are pending to gain a proper understanding of these fundamental effects.

MA 55.15 Fri 10:30 P2

Investigations on the cation distribution of sputtered $NiFe_2O_4$ thin films with high resistivity — •Christoph Klewe[1], Markus Meinert[1], Karsten Kuepper[2], Elke Arenholz[3], Arunava Gupta[4], Jan-Michael Schmalhorst[1], Timo Kuschel[1], and Günter Reiss[1] — [1]University of Bielefeld, Germany — [2]University of Osnabrück, Germany — [3]Advanced Light Source, Lawrence Berkeley National Laboratory, CA 94720, USA — [4]University of Alabama, Tuscaloosa Alabama, USA

Oxidic compounds of the ferrite class have attracted a lot of attention due to their potential insulating and ferro(i)magnetic properties. One promising candidate for a wide range of spintronic and spincaloric applications is the inverse spinel ferrite $NiFe_2O_4$.

We investigated the optical and electronic properties of $NiFe_2O_4$ thin films prepared by reactive dc magnetron co-sputtering. From conductivity measurements a high resistivity was deduced, while the temperature dependence revealed a significantly low activation energy, which is about one order of magnitude smaller than the gap energy determined by optical spectroscopy. X-ray photoelectron spectroscopy (XPS) studies gave information about the cation distribution of the sputtered films. X-ray absorption spectroscopy (XAS) and both x-ray magnetic circular dichroism (XMCD) and linear dichroism (XMLD) allowed to determine the element specific moments and gave additional information on the cation distribution. The results display a full structural inversion and a high structural quality for the investigated films, promoting a utilization in spincaloritronic devices.

MA 55.16 Fri 10:30 P2

Thermoelectrical effects and magnetic anisotropy in GaMnAs thin films — •Ivan Soldatov[1], Nadezda Panarina[1], Rudolf Schäfer[1,2], Christian Hess[1], Sibylle Meyer[2], Wolfgang Limmer[3], Wladimir Schoch[3], and Ludwig Schultz[1,2] — [1]IFW-Dresden, Institute for Solid State Research, D-01171 Dresden, Germany — [2]Institute for Materials Science, TU Dresden, Mommsenstraße 9, D-01069 Dresden, Germany — [3]Universität Ulm, D-89081 Ulm, Germany

We performed a comprehensive investigation of thermoelectric (with temperature gradient) and galvanomagnetic (with charge current) effects in magnetic thin films, where the spin Seebeck effect was observed. Thermoelectric measurements were performed using the steady-state technique, The transverse electric signal on the deposited Pt strips (transverse spin Seebeck configuration) was registrated. Signal was registered directly on the GaMnAs. It suggests planar Nernst (PNE), as an origin of the magneto-electric effects observed in the thin ferromagnetic film of GaMnAs. Besides PNE we measured the anomalous Nernst effect (ANE), applying out-of-plane temperature gradient. From those data the anomalous Nernst coefficient was calculated to be not greater then 500*V/K in saturation. The planar Hall effect (PHE) measured in the sample provided us an opportunity to determine the directions of easy axes and temperature dependence of the ratio between the cubic and uniaxial anisotropies in the system. These data are in agreement with conclusions made from observation of the domain structure of the magnetic layer with use of Kerr-microscopy.

MA 55.17 Fri 10:30 P2

Ferromagnetic resonance and anomalous Nernst effect in an individual magnetic nanotube with GaAs core — •Johannes Mendil[1], Daniel Rüffer[2], Florian Heimbach[1], Florian Brandl[1], Tobias Stückler[1], Eleonora Russo-Averchi[2], Anna Fontcuberta i Morral[2], and Dirk Grundler[1,3] — [1]Physik Department E10, TU München, Garching, Germany — [2]LMSC, EPFL, Lausanne, Switzerland — [3]STI, EPFL, Lausanne, Switzerland

Nanomagnetism and magnetic domain walls play a key role in new visionary concepts, such as the racetrack memory [1]. We present a comprehensive study on ferromagnetic nanotubes (NTs) that allow to study vortex wall formation while avoiding the Bloch point structure existing in magnetic nanowires [2]. For this, a few 10 nm thick ferromagnetic shell (CoFeB or Ni) was deposited on a 10-to-20-μm-long GaAs nanowire. Anisotropic magnetoresistance data show well distinguishable signatures of magnetization switching. Under local laser heating we observe spike-like voltages that we attribute to the anomalous Nernst effect and an NT segment with an azimuthal magnetization. Following this, the chirality of a vortex state can be reconstructed during reversal. Additionally, electrically detected ferromagnetic resonance experiments reveal a series of spin-wave resonances. We will compare our results on individual CoFeB NTs to recently considered Ni NTs [3,4]. The work was supported by GR1640/5-1 in SPP 1538.

[1] S.S.P. Parkin et al., Science 320, 190 (2008); [2] R. Hertel et al., J. Magn. Mater. 278, L291 (2004); [3] D. Rüffer et al., Nanoscale 4, 4989 (2012); [4] A. Buchter et al., Phys. Rev. Lett. 111, 067202 (2013)

MA 55.18 Fri 10:30 P2

Thermal spin transfer torque in vortex state structures — •Michael Vogel[1], Ajay Gangwar[1], Susanne Brunner[1], Stefan Günther[1], Jean-Yves Chauleau[1], Claudia Mewes[2], Tim Mewes[2], Georg Woltersdorf[3], and Christian Back[1] — [1]U Regensburg, Regensburg, Germany — [2]U Alabama, Tuscaloosa, USA — [3]MLU Halle, Halle, Germany

It has recently been proposed that temperature gradients in magnetic structures can induce a thermal spin transfer torque (thermally induced STT) [J.C. Slonczewski, Phys. Rev. B 82, 054403 (2010)].

We study thermally induced spin-currents in lateral devices. In particular we will address the motion of a magnetic vortex core in a ferromagnetic square in the Landau state when subjected to a temperature gradient. We have modified our open source micromagnetic simulation package (M3) to include thermal spin transfer torque as suggested in [K.M.D. Hals, A. Brataas, and G.E.W. Bauer, Solid State Communications 150, 461-465 (2010)]. To test this simulator we compare the magnetization dynamics induced in a nanometer sized Permalloy square subjected to voltage driven STT [M. Najafi, et al., J. Appl. Phys. 105, 113914 (2009)] and thermally driven STT. We have also studied the dependence of the vortex motion as a function of the applied temperature gradient and the size of the Permalloy sample. The motion of the core can be compared to analytic approximations [B. Krüger, et al., Phys. Rev. B 76, 224426 (2007)] Further we have investigated the behavior of such vortex cores at the MAXYMUS scanning transmission X-ray microscopy (STXM) beam line at Bessy, Berlin.

MA 55.19 Fri 10:30 P2

***Ab initio* investigation of the tunneling magneto Seebeck effect** — •Christian Franz, Michael Czerner, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, Giessen, Germany

The Seebeck coefficient describes the thermoelectric voltage induced in a junction by a temperature gradient. In a magnetic tunnel junction the Seebeck coefficient depends on the relative orientation of the magnetizations. This is termed tunneling magneto-Seebeck effect (TMS) or magneto-thermoelectric power. It is defined in analogy to the tunnel magnetoresistance and belongs to the research field of spin caloritronics. The TMS has been predicted theoretically [1] and confirmed experimentally [2].

In this contribution we show *ab initio* results for the TMS in Fe_xCo_{1-x}/MgO/Fe_xCo_{1-x} tunnel junctions [3]. We use a non-equilibrium Green's function method for the transport properties and the coherent potential approximation with vertex corrections to describe the alloys [4]. We investigate the TMS for varying alloy composition, barrier thickness, and temperature. We find that the TMS depends sensitively on the parameters, in particular the alloy composition. This behavior can be traced back to the respective dependence of the transmission function.

[1] M. Czerner et. al, Phys. Rev. B 83, 132405 (2011)
[2] M. Walter et. al, Nat. Mater. 10, 742 (2011)
[3] C. Franz et. al, Phys. Rev. B 88, 094421 (2013)
[4] C. Franz et. al, J. Phys.: Condens. Matter 25, 425301 (2013)

MA 55.20 Fri 10:30 P2

Spin-dependent hot electron lifetimes of 3*d* ferromagnets — •Marko Wietstruk[1], Kristian Döbrich[2], Cornelius Gahl[1], Andreas Goris[1,2], and Martin Weinelt[1] — [1]Freie Universität Berlin, FB Physik — [2]Max-Born-Institut, Berlin

Hot electrons excited few 100 meV above the Fermi energy (E_F) play a major role in, e.g., spin injection and optically induced magnetization dynamics. Also spin-dependent transport relies on the difference in hot electron lifetimes of majority and minority electrons. While theory proposes large lifetime asymmetries near E_F, only very few experimental evidence is given.

In time- and spin-resolved two-photon photoemission experiments (2PPE) we investigated laser induced hot electrons of the 3*d* ferromagnets Fe, Co and Ni. Their lifetimes were determined by simulations using optical Bloch equations.

In contrast to the theory we found a significantly smaller difference between majority and minority lifetimes that decreases even further when approaching E_F. This discrepancy can be explained by considering secondary electrons as well as exchange scattering [1].

[1] A. Goris *et al.*, Phys. Rev. Lett. **107**, 026601 (2011)

MA 55.21 Fri 10:30 P2

Temperature dependent sign change in tunnel magnetoresistance of magnetic tunnel junctions with one magnetite electrode — •Luca Marnitz[1], Karsten Rott[1], Stefan Niehörster[1], Christoph Klewe[1], Daniel Meier[1], Matthäus Witziok[2], Andreas Krampf[2], Olga Schuckmann[2], Tobias Schemme[2], Karsten Kuepper[2], Joachim Wollschläger[2], Günter Reiss[1], and Timo Kuschel[1] — [1]Bielefeld University, Germany — [2]Osnabrück University, Germany

Due to its high spin polarization and Curie temperature, magnetite (Fe_3O_4) is a promising material for room temperature applications in spintronics. Despite these promising features, MTJs using magnetite have not yet shown a large TMR value, the largest being -27% in CoFe/Al_2O_3/MgO/Fe_3O_4/Al_2O_3 (001) junctions[1]. Magnetite grown on MgO shows signs of an interdiffusion of Mg from the substrate through the magnetite at temperatures between 250 and 350°C[2].

We have studied this effect by annealing CoFeB/MgO/Fe_3O_4/MgO (001) MTJs at different temperatures and observed a sign change from a negative TMR to a positive TMR. Additionally, MTJs with magnetite thin films treated by Ar etching showed a vastly increased TMR value of up to -12% for an annealing temperature of 230°C from a starting value of about -1%. A good foundation for further research is provided, including MTJs with two magnetite electrodes with an additional NiO pinning layer and different barrier materials.

[1] T. Kado, Appl. Phys. Lett. 92, 092502 (2008)
[2] Y. Gao et al., J. Mater. Res. 13, 2003 (1998)

MA 55.22 Fri 10:30 P2

Field and temperature dependence of spin fluctuations in $ZrZn_2$ — •Pascal Reiss, Yang Zou, Gilbert G. Lonzarich, and F. Malte Grosche — Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge, CB3 0HE, United Kingdom

$ZrZn_2$ is a low temperature band ferromagnet ($T_c \approx 28$ K), which displays non-Fermi liquid transport properties over a wide temperature range: above $T_{FL} \approx 1$ K and up to T_c, the electrical resistivity follows a power-law temperature dependence with an exponent 5/3, whereas the electronic contribution to the thermal resistivity is linear in temperature. This has been explained in terms of a a magnetic fluctuation model, which includes a self-consistent renormalisation for the magnetic susceptibility [1, 2].

Applied magnetic fields up to 8 T have been observed to increase the cross-over temperature T_{FL} to ~ 6 K. Previous calculations did not include effects of magnetic fields. Here, we will present the results of an extended calculation, which accounts for the role of applied field, allowing a comparison between high field resistivity measurements and the predictions of a magnetic fluctuation model.

[1] G. G. Lonzarich and L. Taillefer, J Phys C: Solid State Phys **18**, 4339-4371 (1985)
[2] R. Smith et al., Nature **455**, 1220-1223 (2008)

MA 55.23 Fri 10:30 P2

Spin-orbit torques in FePt/Pt films from first principles — •Guillaume Géranton, Frank Freimuth, Stefan Blügel, and Yuriy Mokrousov — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Spin-orbit torques in ordered FePt/Pt thin films are investigated from Kubo linear response theory based on the first-principles electronic structure obtained within density functional theory (DFT). FePt/Pt thin films are identified as good candidates for spintronics applications for two reasons: First, large magnetocrystalline anisotropy values were reported in FePt. This suggests that the spin-orbit interaction is strong in this alloy. Thus, breaking of structural inversion symmetry in FePt/Pt films gives rise to relatively large spin-orbit torques (SOTs) on the magnetization. Second, FePt films grow pseudomorphically on Pt(001) substrate. The atomistic structure of FePt/Pt films can thus be well controlled and a high level of reproducibility is possible with respect to magnetic properties. In order to understand the mechanisms underlying the SOTs in FePt/Pt films, we compute the atom-resolved torkance and atom-resolved spin current flux for both even and odd parts of the torkance.

MA 55.24 Fri 10:30 P2

Parametric excitation of spin wave dynamics in a Permalloy nanoellipse — •Philipp Seibt[1], Henning Ulrichs[1], Vladislav Demidov[1], Sergej Demokritov[1], and Sergei Urazhdin[2] — [1]Institut für Angewandte Physik, Universität Münster, Corrensstraße 2-4, 48149 Münster, Germany — [2]Department of Physics, Emory University, Atlanta, GA 30322, USA

The excitation of spin waves with a desired spatial structure is of both fundamental interest and key importance for designing devices utilizing spin dynamics. Parametric excitation is a non-linear process that can access a wide range of spin wave modes. Here we investigate using micro-focus Brillouin light scattering spectroscopy parametrically excited spin waves in a Permalloy nanoellipse. We show that modes localized at the edges of the ellipse have an anomalous spatial distribution and a significantly higher excitation threshold compared to modes localized at the center. We are able to qualitatively explain these results using micromagnetic simulations. Our work demonstrates that certain spin wave modes are highly sensitive to small deviations in sample properties such as saturation magnetization and thickness.

MA 55.25 Fri 10:30 P2

Determination of the Spin Hall Angle using Time and Spatially Resolved Ferromagnetic Resonance in Metallic Bi-layers — •Martin Decker[1], Christian Back[1], and Georg Woltersdorf[2] — [1]Department of Physics, University of Regensburg, 93053, Germany — [2]Department of Physics, MLU Halle-Wittenberg, 06099, Germany

We investigate the spin Hall effect in different ferromagnet(FM)/normal(NM) metal bi-layers and determine the spin Hall angle of the normal metal. Ferromagnetic Resonance (FMR) measurements are performed on a micro-structured bi-layer. The linear response of the magnetization to ac magnetic fields in the GHz range, created by a microstructured coplanar waveguide, is measured using time and spatially resolved Kerr microscopy. A dc current is applied to the bi-layer and causes the injection of a spin current from the normal metal (NM) into the ferromagnet (FM). This spin current induces a spin torque acting on the magnetization which in turn modifies the linewidth of the FMR signal. Measurements of the linewidth as a function of the applied current provide access to the spin Hall angle of the NM [1, 2]. In contrast to the widely used technique of spin pumping, our method also allows to study normal metals that do not have a large spin mixing conductance. We determine the Spin Hall angle of Platinum, Gold and Tantalum, using Permalloy as a ferromagnet.

[1] K. Ando et al., PRL 101, 036601 (2008).
[2] V.E. Demidov et al., APL 99, 172501 (2011).

MA 55.26 Fri 10:30 P2

Collective GHz excitations of Skyrmions and spin helices — •Ioannis Stasinopoulos[1], Thomas Schwarze[1], Andreas Bauer[2], Helmuth Berger[3], Johannes Waizner[4], Markus Garst[4], Christian Pfleiderer[2], and Dirk Grundler[1,5] — [1]Physik-Department E10, TU München, Garching, Germany — [2]Physik-Department E21, 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. They emerge in chiral-magnets, e.g. MnSi, at approximately 28K and arrange in a hexagonal lattice with typical lattice constants of several tens of nm. Due to spin transfer torque coupling of the Skyrmion lattice with electrical currents a tunable chiral-magnet based device could thus be obtained. 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. We study the temperature dependence and dispersion of the dynamics both in the ordered phases and above T_c. This investigation opens the way towards Skyrmion-GHz devices. Financial support by the DFG via TRR80 and NIM is acknowledged.

MA 55.27 Fri 10:30 P2

Chiral magnetic resonances of Skyrmions and helices — •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, Institure de physique de la matière complexe, Lausanne, Swizerland — [5]STI, EPFL, Lausanne, Switzerland

Chiral magnets realize skyrmionic and helical magnetic textures. We study theoretically their microwave excitations driven by an oscillating magnetic or electric field. Extending the theory for ferromagnetic resonance (FMR) to the present case, we determine the position and the weight of the resonance frequencies including the effect of demagnetization fields and dipolar interactions. In contrast to the single Kittel mode present in polarized ferromagnets, we find multiple modes within the helical and skyrmion lattice phase with a characteristic dependence on the direction of both the applied static as well as the ac fields. Our theory is in quantitative agreement with recent experimental results.

MA 55.28 Fri 10:30 P2

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], Capucine Borrowes[3], Dafiné Ravelsona[3], and Mathias Kläui[1] — [1]Institut of Physics, Johannes Gutenberg-Univesity Mainz, Germany — [2]Singulus Technologies AG, Kahl am Main, Germany — [3]Laboratoire de Physique des Solides, Universite Paris-sud, France

For a racetrack device, an appropriate material composition which is compatible with high TMR MgO-based barriers for readout has been developed. We report on transport measurements on a magnetic nanowire structure consisting of a Ta/CoFeB/MgO-multilayer with a perpendicular magnetic 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 spin torque properties of this multilayer stack for current induced domain wall motion using the current-field equivalence method [1]. Another approach to determine the acting torques is using the 2nd Harmonics signal of an alternating current [2].

[1] J. Heinen et al., Appl. Phys. Lett. 96, 202510 (2010) [2] U. H. Pi et al., APL, 97, 162507 (2010)

MA 55.29 Fri 10:30 P2

A novel approach on imaging current-induced spinwave dynamics — •Johannes Stigloher, Jean-Yves Chauleau, Hans Bauer, Helmut Körner, Georg Woltersdorf und Christian Back — Department of Physics, Universität Regensburg, D-93040 Regensburg, Germany

The spin transfer torque (STT) has been an active field of experimental and theoretical research for the last 15 years. STT is accessed by evidencing the consequences of an applied electric current on different magnetic textures such as domain walls, vortex cores or magnetostatic spinwaves. The latter, evidenced by the pioneer work of Vlaminck and Bailleul (Science 320, 410 (2008)), has shown the ability of determining the parameters in a self-consistent way on a single sample. After addressing this subject using time-resolved scanning Kerr microscopy (TRMOKE), we present a preliminary work on an alternative approach of optical detection of current-induced spinwave dynamics. The principle of the approach is the modulation at a low frequency of the applied current, associated to a dual Lock-in amplifier detection. It allows a substantial noise reduction and a direct access to the effect of spin-polarized currents on spinwave characteristics. Subsequently, this approach would open the possibility to spatially resolved STT in more complicated spinwave profiles.

MA 55.30 Fri 10:30 P2

Bose-Einstein condensation of exchange magnons — •Peter Clausen[1], Dmytro A. Bozhko[1], Vitaliy I. Vasyuchka[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

The technique of parallel parametric pumping is widely used to inject magnons in ferri- and ferromagnetic films. However, the physics of the evolution of a parametrically pumped magnon gas is still under investigation. We report on this evolution by four-magnon scattering

of a non-equilibrium magnon gas in time and wavevector space.

The measurements were performed using a combined microwave and Brillouin light scattering (BLS) setup.

We find two groups of magnons at different positions in time and wavevector space. We identify them with the parametrically pumped magnons and the magnon Bose-Einstein-condensate at the bottom of the magnon spectrum. However, there is a 25 ns long gap between those two magnon groups where no BLS signal is observed.

Our model shows, that this gap in the BLS signal can be explained solely by multi-stage four-magnon scattering from energy minima to minima of high longitudinal BVMSW thickness mode mainly outside of the wavevector detection window of $(0-12)\cdot 10^4$ rad/cm from the experimental setup.

Support by the DFG within the SFB/TRR 49 is gratefully acknowledged.

MA 55.31 Fri 10:30 P2

Femtosecond demagnetization of Nickel/Gold: rotation vs. ellipticity — •Jurij Urbancic, Oliver Schmitt, Moritz Barkowski, Steffen Eich, Jingyi Mao, Sakshath S, Daniel Steil, Mirko Cinchetti, Stefan Mathias, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Using femtosecond time-resolved MOKE to study ultrafast demagnetization is today a standard experimental approach. However, there is still an ongoing debate on the so called optical artifacts in the signal, and when and how true magnetization dynamics is extracted. In our measurements of ultrafast demagnetization of Ni/Au, we have the peculiar situation that the MOKE rotation & ellipticity signals differ by demagnetization constants of a factor of two. In order to distinguish demagnetization from non-magnetic effects, we study this system with different fs-techniques and for varying material compositions.

MA 55.32 Fri 10:30 P2

Ultrafast magnetic and structural dynamics in antiferromagnetic Europium-Telluride — •Christoph Trabant[1,2,3,6], Niko Pontius[1], Karsten Holldack[1], Enrico Schierle[1], Eugen Weschke[1], Torsten Kachel[1], Rolf Mitzner[1], Martin Beye[1], Gunther Springholz[4], Georgi Dakovski[5], Joshua J Turner[5], Stefan Möller[5], Tianhan Wang[5], Alex Gray[5], Markus Hantschmann[5,1], Hermann Dürr[5], Michael Minitti[5], W.S. Lee[5], Yi-De Chuang[5], Zuman Hussain[5], Z.X. Shen[5], Matias Bargheer[3], Daniel Schick[3], Alexander Föhlisch[1,3], and Christian Schüssler-Langeheine[1] — [1]Helmholtz-Zentrum Berlin — [2]II. Physikalisches Institut, Universität zu Köln — [3]Institut für Physik und Astronomie, Universität Potsdam — [4]Institute of Semiconductor and Solid State Physics, Johannes Kepler Universität Linz, Austria — [5]SLAC RSXS collaboration, USA — [6]present address: Institut für Experimentalphysik, FU Berlin

We studied the laser induced ultrafast magnetic and structural dynamics of a metallic 4f semiconductor and antiferromagentic EuTe thin film. The dynamics were mapped using the strong resonant x-ray scattering signal of the antiferromagnetic (001/2) superstructure and (001) structural reflection. Here we show how different excitation scenarios have similiar but at certain delays crucially different influence on the ultrafast magnetic and structural dynamics. The optical pump xray probe measurements have been performed in one experiment at the SXR-beamline of LCLS. Supported by the BMBF through contract 05K10PK2.

MA 55.33 Fri 10:30 P2

Transport effects in metals driven by the nonequilibrium in electron temperatures and chemical potentials — •Linda Thesing, Benedikt Y. Mueller, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

By exciting a metal sample with an ultrashort laser pulse, not only the electron temperature but also the chemical potential are spatially disturbed. We developed a μT model for a metallic slab which determines the dynamics of electron and phonon temperatures. In addition, we trace the chemical potential explicitly as an dynamic quantity. Thus, our model allows for additional transport effects, like Seebeck or Peltier effect, which would not be accessible with an ordinary two temperature model (2TM) [1]. The μT model is based on a reformulation of the 2TM and the heat and particle fluxes are determined by the Boltzmann equation within a relaxation approach. Our model also promises insights in the magnetization dynamics, when spin-up and spin-down electrons are considered separately. Spin-flip scattering processes driven by different chemical potentials [2,3] can then be traced simultaneously with transport effects.

[1] Anisimov et al., Sov. Phys.-JETP 39, 375 (1974)
[2] Mueller et al., PRL 111, 167204 (2013)
[3] Mueller et al., NJP 13, 123010 (2011)

MA 55.34 Fri 10:30 P2

Single NV center spin driven by resonant and near-resonant microwave field — •Ganesh Rahane[1], Andrii Lazariev[1], Perunthiruthy Madhu[2], and Gopalkrishnan Balasubramanian[1] — [1]Max Planck Research Group "Nanoscale Spin Imaging", Max Planck Instiute for Biophysical Chemistry, Goettingen, Germany — [2]Dept. of Chemical Sciences, TIFR, Mumbai, India

Optical initialization and detection of nitrogen-vacancy(NV) center spin state at room temperature makes NV center system suitable for variety of applications. The dressed state transitions are important for polarization transfer from NV center spin to surrounding spin bath under Hartmann Hahn condition. The resonant and near-resonant field driving for two-level system corresponding to single quantum transition from single NV center ground state is studied. The Autler-Townes effect and Multi-photon processes are observed. The dependence of Autler-Towenes and Multi-photon transitions on strength and detuning of resonant and near-resonant field is studied.The single quantum transition in NV center ground state is good candidate for qubit because simulation performed for bichromatically driven two level-system matches closely with the experimental result.

MA 55.35 Fri 10:30 P2

Ultra low magnetic damping in half metalic CrO_2 — •Markus Härtinger[1], Tim Mewes[2], Arunava Gupta[2], Georg Woltersdorf[1,3], and Christian Back[1] — [1]Department of Physics, Universität Regensburg, 93040 Regensburg, Germany — [2]University of Alabama, Tuscaloosa, U.S.A. — [3]Department of Physics, Martin-Luther-Universität Halle, 06099 Halle(Saale), Germany

Chromiumdioxide (CrO_2) is one of the most interesting half-metallic ferromagnets with a large spin polarization and a high Curie temperature. It was studied for a long time and used for various magnetic storage devices. Since few years it is possible to grow high quality single crystalline CrO_2 films by chemical vapour deposition (CVD).

We report on the magnetic properties and anisotropies of a 29 nm thick CrO_2 (100) layer grown on a TiO_2 (001) substrate. The magnetic properties are determined by performing ferromagnetic resonance (FMR) measurements in a large frequency range covering 2 to 40 GHz. We find extremely narrow resonance lines corresponding to a very small Gilbert damping constant of approximately $\alpha \approx 0.0002-0.0004$. Our angular dependent measurements also show that two magnon scattering dominates the relaxation when the magnetization lies in the sample plane.

MA 55.36 Fri 10:30 P2

Ion Beam Induced Periodic Surface Defects: The Transition from a Thin Film to a Magnonic Crystal — •Manuel Langer[1,2], Rodolfo A. Gallardo[3], Anja Banholzer[1,2], Andreas Jansen[1,2], Tobias Schneider[1,2], Kai Wagner[4], Vladislaw Demidov[5], Sergej O. Demokritov[5], Pedro Landeros[3], Kilian Lenz[1], Jürgen Lindner[1], and Jürgen Fassbender[1,2] — [1]HZDR, 01328 Dresden — [2]TU Dresden, 01069 Dresden — [3]UTFSM Valparaíso, Chile — [4]University Duisburg-Essen, 47057 Duisburg — [5]University Münster, 48149 Münster

Periodic arrays of magnetic stripe defects are fabricated by Cr^+ ion implantation on a 30 nm permalloy film. Modifying the mean ion penetration depth, the defect height can be controlled, which allows an investigation of the gradual transition from a magnetic thin film towards a magnonic crystal.

Spin wave dispersion and two-magnon scattering are studied using brillouin light scattering (BLS) as well as broadband ferromagnetic resonance (FMR). The obtained results are corroborated by theoretical calculations based on a perturbation theory.

MA 55.37 Fri 10:30 P2

Ultrafast magnetization dynamics probed by Lorentz microscopy with temporally structured illumination — •Jan Gregor Gatzmann[1], Vladyslav Zbarsky[2], Markus Münzenberg[2], Sascha Schäfer[1], and Claus Ropers[1] — [1]IV. Physikalisches Institut, Universität Göttingen — [2]I. Physikalisches Institut, Universität Göttingen

Combining transmission electron microscopy (TEM) with ultrashort sample excitation allows for the observation of ultrafast dynamics at the nanoscale. Whereas ultrafast laser-pump/ electron-probe experiments were recently developed, the benefits of temporally structured illumination with femtosecond pulse trains in a conventional TEM remain rather unexplored. Here, we use Lorentz microscopy to study the irreversible magnetization dynamics in iron thin-films triggered by femtosecond optical pulses. At low excitation fluence, we observe a laser-induced switching of ripple domains, with characteristic patterns shaped by pinned domain walls. At a well-defined fluence threshold, the generation of magnetic vortex-antivortex networks is initiated. The dynamical nature of these processes is investigated utilizing femtosecond pulse pairs with variable delay times.

MA 55.38 Fri 10:30 P2

Ultrafast magnetization dynamics of Copper-doped FePt thin films for different Copper contents and fluences. — •Oliver Schmitt[1], Daniel Steil[1], Sabine Alebrand[1], Stefan Mathias[1], Mirko Mirko[1], Martin Aeschlimann[1], Fabian Ganss[2], Christoph Brombacher[2], and Manfred Albrecht[2] — [1]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

Future magnetic data storage devices require high density information packing. A typical material is an FePt thin film with high perpendicular magnetic anisotropy [1]. It is chemically ordered in the L10 phase. Here we investigate this material doped with different Cu contents from 15 to 25 percent using the femtosecond time-resolved magneto-optical Kerr-Effect. For all samples the speed of demagnetization increases very strongly for the highest magnetization quenchings. This behaviour has been proposed for 3d ferromagnets like Ni oder Co [2]. Moreover, we find for the FePt:Cu sample with 25% Cu a transient ferromagnetic-like state on ultrafast and picosecond timescales.

[1] S. H. Sun, C. B. Murray, D. Weller, L. Folks and A. Moser, Science 287, 1989 (2000). [2] B. Koopmans, G. Malinowski, F. Dalla Longa, D. Steiauf, M. Fähnle, T. Roth, M. Cinchetti and M. Aeschlimann, Nature Materials 9, 259*265 (2010)

MA 55.39 Fri 10:30 P2

Spin current in a ferromagnetic chain — •Seyyed Ruhollah Etesami[1,2], Levan Chotorlishvili[2], Alexander Sukhov[2], and Jamal Berakdar[2] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

The long-range thermal injection of the spin current from a ferromagnet (FM) to the adjacent normal metal (NM), known as spin Seebeck effect (SSE), has paved the way for developing more efficient thermoelectric devices. Since the FM-NM interface plays the key role in SSE, the focus of the studies mainly is on the FM-NM interface and the ferromagnet is modeled just as a single domain. But in order to understand SSE the knowledge of spin current generated in the ferromagnet is also indispensable, although it's not yet well understood. In this study we were interested to turn our focus on the generated spin current in the ferromagnet part. We modeled ferromagnet part as a chain of magnetic moments under a temperature gradient. We used the stochastic Landau-Lifshitz-Gilbert (LLG) equation to describe the dynamic of the ferromagnet chain. The generated spin current along the chain at different circumstances was studied. Finally,the FM-NM interface effect was studied by adding the spin pumping and spin-transfer torques to the LLG equation.

MA 55.40 Fri 10:30 P2

Element-specific magnetization dynamics in Gd doped Ni81Fe19 films — •Ruslan Salikhov[3], Radu Abrudan[1], Florian Römer[3], Florin Radu[2], Ralf Meckenstock[3], Hartmut Zabel[1], and Michael Farle[3] — [1]Ruhr-Universität Bochum, Germany — [2]Helmholtz Zentrum Berlin, Germany — [3]Universität Duisburg-Essen, Germany

We have studied magnetization dynamics in Ni81Fe19 films doped by Gd with different concentrations (5, 9 and 13 at.%) using ferromagnetic resonance (FMR) [1] and time-resolved x-ray resonant magnetic scattering (tr-XRMS) implemented at the Helmholtz Zentrum Berlin [2]. At room temperature two antiferromagnetically coupled sublattices Fe (Ni) and Gd show identical response after magnetic field pulse excitation, having similar Landau-Lifshitz (LL) relaxation rate (λ) and precessional frequency (f). The FMR dimensionless damping parameter α increases with increasing Gd content. However, λ obtained from the tr-XRMS shows the opposite trend with increasing Gd concentration. At low temperatures (100 and 50 K) we have found that Fe and Gd sublattices precess noncollinear (with different precessional angles in respect to initial state). Noncollinear precession of the Fe and Gd magnetic moments accompanied with increase in both λ and f. Our results will be discussed in the frame of the "s-d exchange model" [3] and the "slow relaxing" impurity model [4].

[1] F. Römer et al., APL. 100, 092402 (2012). [2] R. Salikhov et al., PRB 86, 144422 (2012). [3] B. Heinrich et al., Phys. Stat. Sol. 23, 501 (1967). [4] G. Woltersdorf et al., PRL. 102, 257602 (2009).

MA 55.41 Fri 10:30 P2

Femtosecond demagnetization of Nickel/Gold: rotation vs. ellipticity — •Jurij Urbancic, Oliver Schmitt, Moritz Barkowski, Steffen Eich, Jingyi Mao, Sakshath Sadashivaiah, Daniel Steil, Mirko Cinchett, Stefan Mathias, and Martin Aeschliman — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, DE

Using femtosecond time-resolved MOKE to study ultrafast demagnetization is today a standard experimental approach. However, there is still an ongoing debate on the so called optical artifacts in the signal, and when and how true magnetization dynamics is extracted. In our measurements of ultrafast demagnetization of Ni/Au, we have the peculiar situation that the MOKE rotation & ellipticity signals differ by demagnetization constants of a factor of two. In order to distinguish demagnetization from non-magnetic effects, we study this system with different fs-techniques and for varying material compositions.

MA 55.42 Fri 10:30 P2

DC-Inverse Spin Hall Effect in Permalloy/Normal Metal Bilayers — •Martin Obstbaum[1], Markus Härtinger[1], Hans G. Bauer[1], Thomas Meier[1], Fabian Swientek[1], Christian H. Back[1], and Georg Woltersdorf[1,2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg,93040 Regensburg, Germany — [2]Physik, Martin Luther-Universität Halle, von Danckelmann-Platz 3, 06120 Halle

We present a study of the dc-voltage generation by the inverse spin Hall effect (ISHE) and the anisotropic magnetoresistance (AMR) in permalloy/normal metal bilayers at ferromagnetic resonance (FMR). We use a coplanar waveguide (CPW) structure implementing different excitation geometries. At FMR spin currents with a small dc-component are injected into the normal metal layer due to the spin pumping effect. Measurements of permalloy/platinum and permalloy/gold show that the ISHE and the AMR effect can only be separated for certain conditions. Furthermore, we point out that a conductive layer (e.g. Pt, Au) attached to the permalloy layer generates a significant additional Oersted field in experiments using a CPW. Our study provides a robust experimental basis in the quest for materials showing a large spin Hall angle. We present a reliable determination of spin Hall angles for platinum and gold and a study of ISHE in tantalum, tungsten and metal alloys such as copper-bismuth. Moreover, the contributions to voltages measured at FMR have been studied as a function of temperature and the results are compared to theoretical models.

MA 55.43 Fri 10:30 P2

Microscopic spin dynamics with coupling to a phonon bath — •Svenja Vollmar[1,2], Alexander Baral[1], and Hans Christian Schneider[1] — [1]Department of Physics and Research Center of OPTIMAS, University of Kaiserslautern — [2]Graduate School of Excellence Materials Science in Mainz

To describe different aspects of magnetization dynamics, from magnetization precession to demagnetization dynamics, phenomenological models are used with considerable success. These usually include the spin-orbit interaction and treat certain interactions involving the spin degrees of freedom by introducing baths. Here we investigate different aspects of a s-d(f) model that explicitly includes itinerant charge carriers with spin, the spin-orbit coupling, and the exchange coupling to a localized spin system. Importantly, the interaction with the phonon bath is derived microscopically.

First, we focus on the interaction between antiferromagnetically coupled itinerant carriers and a macroscopin. We calculate the microscopic spin dynamics including a Rashba spin-orbit coupling and the coupling to a phonon bath. Additionally, we extrapolate dephasing and magnetization times.

Next, we investigate the intrinsic spin dynamics of a Heisenberg model coupled to a bath. We derive equations of motion for the excitations in the spin system (magnons) in order to study their relaxation dynamics. The coupling to a phonon bath is described by using a Lindblad-operator formalism.

MA 55.44 Fri 10:30 P2

Magnetic Damping: Domain Wall Dynamics vs. Local Ferromagnetic Resonance — •Tobias Weindler, Hans Bauer, Robert Islinger, Benedikt Boehm, Jean-Yves Chauleau, and Christian Back — Department of Physics, Universität Regensburg, D-93040 Regensburg, Germany

The damping coefficient (α) is a crucial quantity for any magnetization dynamics study. It plays a major role especially in domain wall (DW) dynamics where DW displacement is directly related to relaxation effects. For DWs submitted to magnetic fields, the domain wall mobility in the steady state regime is inversely proportional to α whereas it is proportional in the steady precessional regime. For current-induced DW motion, the mobility in the steady state regime is proportional to the ratio between the non-adiabaticity and the relaxation. However significant discrepancies have been reported for values of α measured in extended magnetic layers by ferromagnetic resonance (FMR) and when is used as an adjustment parameter in micromagnetic simulation of DW motion in magnetic stripes. In our study, we experimentally address this issue by consistently assessing α in Ni80Fe20 (Permalloy) from two different approaches on the same nanostructure. On one hand we use time-resolved scanning Kerr microscopy (TRMOKE) to perform local FMR on single Ni80Fe20 nanostripes. On the other hand, in the same nanostripes, domain walls are injected and field-driven displacements are evidenced and analysed by wide-field Kerr microscopy.

MA 55.45 Fri 10:30 P2

Time-resolved soft X-ray microscopy of magnetic nanostructures at the P04 beamline of PETRA III — •Philipp Wessels[1], Johannes Ewald[2], Marek Wieland[1], Thomas Nisius[2], Gennaro Abbati[2], Stefan Baumbach[2], Jens Viefhaus[3], Thomas Wilhein[2], and Markus Drescher[1] — [1]Institute for Experimental Physics, University of Hamburg, Germany — [2]Institute for X-Optics, RheinAhrCampus Remagen, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

We present first time-resolved measurements obtained with a new transmission microscope at the soft X-ray beamline P04 of the high brilliance synchrotron radiation source PETRA III.

A nanostructured magnetic permalloy ($Ni_{80}Fe_{20}$) sample can be excited either by making use of a mobile synchronized femtosecond laser system or by a 250 ps electric current pulse via a coplanar waveguide. The full-field soft X-ray microscope successively probes the time evolution of the magnetization in the sample via XMCD spectromicroscopy in a pump-probe scheme. Static and transient magnetic fields are available in the sample plane by permanent magnets and coils to reset the system and to provide external offset fields.

The microscope generates a flat-top illumination field of 20 μm diameter by using a grating condenser and the sample plane is directly imaged by a micro zone plate with < 65 nm resolution onto a 2D gateable X-ray detector to select one particular bunch in the storage ring that probes the dynamic information.

MA 55.46 Fri 10:30 P2

Dispersive Magnon Excitations in $Ca_3Co_2O_6$ — •Pavlo Y. Portnichenko[2], Anil Jain[1], Hoyoung Jang[1], Alexandr Ivanov[3], Bernhard Keimer[1], and Dmytro S. Inosov[2] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart, Germany. — [2]Institut für Festkörperphysik, TU Dresden, Zellescher Weg 16, D-01069 Dresden, Germany. — [3]Institut Laue-Langevin, 6 rue Jules Horowitz, BP 156, 38042 Grenoble Cedex, France.

The geometrically frustrated trigonal cobaltate $Ca_3Co_2O_6$ is considered to be a model system for a one-dimensional Ising-like antiferromagnet. Its crystal structure represents a hexagonal arrangement of one-dimensional chains, which consist of alternating nonmagnetic CoO_6 octahedra and CoO_6 trigonal prisms with a large magnetic moment.

Using inelastic neutron scattering, we have observed a quasi-one-dimensional dispersive magnetic excitation in the frustrated triangular-lattice spin-2 chain oxide $Ca_3Co_2O_6$. At the lowest temperature ($T = 1.5$ K), this magnon is characterized by a large zone-center spin gap of ~ 27 meV, which we attribute to the large single-ion anisotropy, and disperses along the chain direction with a bandwidth of ~ 3.5 meV. In the directions orthogonal to the chains, no measurable dispersion was found. With increasing temperature, the magnon dispersion shifts towards lower energies, yet persists up to at least 150 K, indicating that the ferromagnetic intrachain correlations survive up to six times higher temperatures than the long-range interchain antiferromagnetic order.

MA 55.47 Fri 10:30 P2

Majorana spin liquid and dimensional reduction in Cs_2CuCl_4 — Tim Herfurth[1,2], •Simon Streib[1], and Peter Kopietz[1,2] — [1]Institut für Theoretische Physik, Universität Frankfurt, Max-von-Laue Strasse 1, 60438 Frankfurt, Germany — [2]Department of Physics, University of Florida, Gainesville, Florida 32611, USA

The low-temperature behavior of the magnetic insulator Cs_2CuCl_4 can be modeled by an anisotropic triangular lattice spin-1/2 Heisenberg antiferromagnet with two different exchange couplings J and $J' = J/3$. We show that in a wide range of magnetic fields the experimentally observed field dependence of the crossover temperature T_c for spin-liquid behavior can be explained within a mean-field theory based on the representation of spin operators in terms of Majorana fermions. In the spin-liquid regime, the Majorana fermions can only propagate along the direction of the strongest bond, which implies that we are dealing with a quasi-one-dimensional spin-liquid phase. Next, we investigate the coupling of the spin degrees of freedom to phonons for a one-dimensional spin-liquid. To this end, we consider the one-dimensional spin-1/2 Heisenberg antiferromagnet with nearest neighbor exchange interaction and include the magneto-elastic coupling by expanding the exchange interactions up to second order in powers of the phonon coordinates. We present theoretical results for the magnetic field and temperature dependence of the elastic constants and the ultrasonic attenuation rate in the one-dimensional spin-liquid phase.

MA 55.48 Fri 10:30 P2

10th order high-temperature expansion for the susceptibility and the specific heat of spin-s Heisenberg models with arbitrary exchange patterns: Application to pyrochlore and kagome magnets — •J. Richter[1], A. Lohmann[1], and H.-J. Schmidt[2] — [1]University Magdeburg, Germany — [2]University Osnabrueck, Germany

We present the high-temperature expansion (HTE) up to 10th order of the specific heat C and the uniform susceptibility χ for Heisenberg models with arbitrary exchange patterns and arbitrary spin quantum number s. We encode the algorithm in a C++ program available at `http://www.uni-magdeburg.de/jschulen/HTE/` which allows to get explicitly the HTE series for concrete Heisenberg models. We apply our algorithm to pyrochlore and kagome magnets. For the pyrochlore FM we use the HTE to estimate the Curie temperature T_c as a function of the spin quantum number s. We find that T_c is smaller than that for the simple cubic lattice, although both lattices have the same coordination number. For the kagome AFM the influence of the spin quantum number s on χ as a function of renormalized temperature $T/s(s+1)$ is rather weak for temperatures down to $T/s(s+1) \sim 0.3$. On the other hand, the specific heat as a function of $T/s(s+1)$ noticeably depends on s. The characteristic maximum in $C(T)$ is monotonously shifted to lower values of $T/s(s+1)$ when increasing s.

[1] H.-J. Schmidt, A. Lohmann, and J. Richter, Phys. Rev. B 84, 104443 (2011). [2] A. Lohmann, H.-J. Schmidt, and J. Richter, arXiv:1309.0940.

MA 55.49 Fri 10:30 P2

Structural and magnetic phase transitions in antiferromagnetic $PrCaFeO_4$ — •Navid Qureshi[1], Martin Valldor[1,2], Lisa Weber[1], Anatoliy Senyshyn[3], Yvan Sidis[4], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]MPI für Chemische Physik fester Stoffe — [3]Technische Universität München, FRM-II — [4]Laboratoire Léon Brillouin, C.E.A. Saclay

We present a comprehensive study on $PrCaFeO_4$ using macroscopic methods, neutron and x-ray diffraction as well as inelastic neutron scattering. Two single crystals have been grown which exhibit two structural and one magnetic phase transition as seen from single differential thermal analysis and neutron diffraction. In contrast, the very closely related compound $LaSrFeO_4$ stays tetragonal ($I4/mmm$) throughout the whole temperature range [1]. The transition temperature and especially the transition regime of the spin reorientation from an in-plane configuration (like in $LaSrFeO_4$) to the c axis is strikingly different between the two samples suggesting a strong influence of the crystal quality on the magnetic properties. Inelastic neutron scattering reveals a smaller anisotropy gap in the low-temperature magnetic phase, whereas the coupling constants only change for the interplane interaction between the two phases. The spin reorientation and the decreasing gap result from an interplay between magnetostriction and spin-orbit coupling closely connected to the temperature-induced structural changes of lattice constants and octahedral tilts.

[1] N. Qureshi et al., Phys. Rev. B 87, 054433 (2013).

MA 55.50 Fri 10:30 P2

Metamagnetic transitions in U_2Ni_2Sn probed by high-field magnetization and acoustic measurements — •S. Yasin[1], A.V. Andreev[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

Uranium intermetallic compounds are subjects of intensive fundamental research. The competition between exchange interactions, crystal-field and hybridization effects plays a major role in the formation of $5f$ magnetic moments and the magnetic ordering. We report on magnetization and ultrasound measurements on antiferromagnet (T_N = 25 K) U_2Ni_2Sn single crystal in pulsed magnetic fields up to 62 T. At $T = 1.5$ K, three metamagnetic transitions were observed at 30, 40, and 52 T for the magnetic field applied along the c axis. No sign of saturation up to the highest fields was found. Interestingly, the magnetization reaches a value of 1.5 μ_B/f.u. at 60 T which is higher than the uranium magnetic moments (1.05 μ_B at 1.5 K) reported by powder neutron-diffraction. This observation suggests that additional magnetic moments of delocalized electrons are induced by the applied magnetic field. All three metamagnetic transitions are accompanied by pronounced anomalies in the acoustic characteristics. Moreover, in zero magnetic field the sound velocity exhibits an anomaly at T_N. Our results evidence the important role of complex magneto-elastic couplings in this material. The magnetization processes and spin-strain couplings are discussed.

MA 55.51 Fri 10:30 P2

Critical magnetic fluctuations in Heisenberg antiferromagnets — •Kuo Feng Tseng[1], Andrew Walters[1], Thomas Keller[1,2], Sibel Bayrakci[1], and Bernhard Keimer[1] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [2]Max Planck Society Outstation at the Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM-II), D-85747 Garching, Germany

We have performed elastic and inelastic neutron scattering measurements in classical Heisenberg antiferromagnets MnF_2 (3D) and Rb_2MnF_4 (2D) with a Néel temperature T_N of 67.4 and 38.4 K respectively. We utilized high resolution spin-echo and Larmor diffraction techniques at the TRIple axis resonance SPin echo spectrometer (TRISP). By appropriately choosing field geometries at TRISP, we are able to separate the longitudinal and transverse correlations of the critical fluctuations close to T_N with the advantages of neutron ray-tracing method. Determinations of the longitudinal and transverse linewidths (=inverse lifetime) on MnF_2 and Rb_2MnF_4 were obtained at TRISP with extremely high resolution in a micronelectron-volt range. The results and technique open up a new avenue for a re-investigation of underlying physics in the critical phenomena.

MA 55.52 Fri 10:30 P2

Orphan spins on the checkerboard lattice — •Jorge Rehn, Arnab Sen, Alexei Andreanov, and Roderich Moessner — MPIPKS, Dresden, Germany

Geometrically frustrated systems having a Coulomb phase, i.e., a system with a macroscopically degenerate ground state with power law decaying correlations, exhibit interesting low temperature excitations, e.g., in spin ice effectively described by interacting magnetic monopoles, which are created once the ice rules constraints are violated.

The consideration of disorder in systems with a Coulomb phase, such as the effects of dilution of non-magnetic impurities in the composite SCGO, leads to a similar effective picture: the ice rules constraints are violated because a “Orphan Spin” is left alone with non-magnetic impurities as neighbours.

An effective low temperature theory for such system describes the interactions among the Orphan Spins in terms of the correlations in the ground state of the pure system. In this project we show that the effective interactions of Orphan Spins on the checkerboard lattice must be of logarithmic form, if the temperatures are low enough. Monte Carlo simulations have been carried on to investigate the possibility of a spin glass phase. The main numerical results supporting the presence of a spin glass phase transition in this system are shown.

MA 55.53 Fri 10:30 P2

Electron holography on ripple-shaped magnetic permalloy thin films — •Falk Röder[1], Michael Körner[2,3], Monika Fritzsche[2,3], Kilian Lenz[2], Jürgen Lindner[2], Jürgen Fassbender[2,3], and Hannes Lichte[1] — [1]Triebenberg Laboratory, Institute of Structure Physics, Technical University of Dresden, 01062 Dresden, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstr. 400, 01328 Dresden, Germany — [3]Technical University of Dresden, 01062 Dresden, Germany

By means of off-axis electron holography, we study the distribution of the magnetic induction within and around a poly-crystalline permalloy ($Ni_{81}Fe_{19}$) thin film. Its deposition on a silicon substrate with a given periodic surface morphology emerging through concerted Xe^+ ion beam erosion introduces a ripple shape to the permalloy thin film. The created ripple morphology is expected to modify the magnetization distribution within the permalloy and to induce dipolar stray fields. Micro-magnetic simulations estimate those stray fields in the order of only 10 mT. Consequently, their experimental determination at nanometer spatial resolution is highly demanding and requires advanced acquisition and reconstruction techniques such as electron holography. The reconstructed magnetic phase images show magnetized thin films, in which the magnetization direction follows the given morphology. Furthermore, a closer look to the permalloy/carbon interface reveals stray fields at the detection limit of the method in the order of 10 mT, which agrees well with micro-magnetic simulations.

MA 55.54 Fri 10:30 P2

Growth, ferromagnetism and electronic properties of the magnetic oxide EuO on conductive SrTiO3 — •Patrick Lömker[1], Bernardus Ziljstra[1], Christian Caspers[1], Michael Hoppe[1], Andrei Glosovskij[2], Wolfgang Drube[2], Claus M. Schneider[1,3], and Martina Müller[1,3] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich — [2]Petra III, DESY, Hamburg — [3]Fakultät für Physik, Universität Duisburg-Essen

The spin-filter tunnelling effect, which occurs in magnetic insulators like EuO, is an efficient route to generate highly spin-polarized electron currents for spintronic applications. However, only theoretical studies exist for single-crystalline magnetic oxide tunnel barriers, in which band-structure dependent properties are taken into account.

In this regard, we propose a model system based on EuO epitaxially stabilized on Nb-doped SrTiO3(001) (Nb-STO). We succeeded to grow epitaxial ultrathin films ($d = 1 - 15$ nm) of stoichiometric EuO on Nb-STO(001) using oxide molecular beam epitaxy. The structural properties have been analysed by in situ RHEED and LEED, showing a single crystalline growth mode. SQUID measurements display bulk-like ferromagnetic properties ($T_C = 69$ K) for $d > 4$ nm, whereas a reduction of T_C is observed for $d < 4$ nm. Hard X-ray photoelectron spectroscopy experiments reveal the chemical properties and homogeneity of the EuO/Nb-STO heterostructures.

Finally, transport measurements are envisioned to reveal spin filtering in fully epitaxial Euo/STO tunnel junctions.

MA 55.55 Fri 10:30 P2

Behavior of MnSi thin films under hydrostatic pressure — •Josefin Engelke[1], Dirk Menzel[1], Hiroyuki Hidaka[2], Taisei Seguchi[2], and Hiroshi Amitsuka[2] — [1]IPKM, TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig, Germany — [2]Graduate School of Science, Hokkaido University, Sapporo 060-0810, Japan

Recently, thin films of the B20 compound MnSi became subject of great interest, since the magnetic properties of bulk MnSi can be modified by inducing uniaxial anisotropy. In comparison to the bulk the critical fields are enhanced and the skyrmion phase is found to be enlarged within the magnetic phase diagram [1],[2]. Furthermore the ordering temperature of 43 K is considerably higher than in bulk ($T_{ord,bulk}$ = 29 K).

Under applied hydrostatic pressure the ordering temperature of bulk MnSi decreases with increasing pressure, and a non-Fermi liquid behavior for pressures exceeding 12 kbar occurs. At 14.6 kbar the magnetic order is completely suppressed [3].

We present resistivity measurements on MnSi thin films under applied pressure of up to around 40 kbar. Qualitatively, the behavior is similar to bulk MnSi. However, the critical pressure is considerably enhanced. Non-Fermi liquid behavior evidenced by a $T^{3/2}$ behavior of the resitivity is observed, when the pressure reaches 33 kbar.

[1] J. Engelke et al., J. Phys. Soc. Japn. 81, 124709 (2012). [2] M. N. Wilson et al., Phys. Rev. B 86, 144420 (2012). [3] C. Pfleiderer et al., Phys. Rev. B 55, 8331 (1997).

MA 55.56 Fri 10:30 P2

Spin-reorientation transition and domain structure in Ni_xPd_{1-x} alloys — •Daniel Gottlob[1,2], Ingo Krug[1], Hatice Doğanay[1], Florian Nickel[1], Stefan Cramm[1], and Claus Schneider[1,2] — [1]Forschungszentrum Juelich, 52425 Juelich — [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 the magnetic anisotropy. Aberration-corrected LEEM-PEEM with its high spatial resolution is the ideal tool to investigate the magnetic domain-structure and do composition-gradient dependent studies on microwedges and thin films. By alloying Palladium into Nickel the epitaxial strain of a thin film may be varied and the critical film thickness at which an (i) SRT occurs can be controlled. We prepared microwedged and continuous NiPd thin films in situ by molecular beam epitaxy. Both elements have been co-deposited using an aperture-shadowing technique to create a thickness wedge on the sample. We present a study by aberration corrected LEEM-PEEM at the FZ Jülich Beamline UE56/1-sgm at BESSY, mapping the SRTs and magnetic phases via the domain structures of NiPd alloy films between 10 and 100 monolayers.

MA 55.57 Fri 10:30 P2

Vortex state free layer tunnelmagnetoresistance-sensors — •Frederick Casper[1,2], Ronald Lehndorff[3], Johannes Paul[3], and Mathias Kläui[2] — [1]Johannes Gutenberg University, Institute for Inorganic and Analytical Chemistry, D-55099 Mainz, Germany — [2]Johannes Gutenberg University, Institute for Physics, D-55099 Mainz, Germany — [3]Sensitec GmbH, D-55131 Mainz, Germany

Within the last years magnetoresistive sensors based on the tunnel magneto resistance (TMR) effect have gained a great deal of attention for industrial application. One of their advantages compared to other magnetic sensors is a large signal amplitude, which allows for a reduction of read-out electronics. Here we present a concept for a vortex state free layer TMR sensor. These vortex states are used to linearize the output signal and also have a very narrow hysteresis. Therefore they seem to be ideal for position measurement application. The samples were made on a thermally oxidized 5" silicon wafer by dc magnetron sputtering using a conventional TMR stack: Ta/Ru seed /IrMn 8.9 nm/ CoFe 3 nm/ Ru 0.74 nm/ CoFeB 3.1 nm/ MgO X nm/ CoFeB 3.2 nm / NiFe 15 nm/ Ta cap. The films were annealed in an applied magnetic field of 10 kOe for 1h at 265°C. Circular junctions with a diameter of 2 μm were formed using photo lithography. A sensor element compromises 20 of such junctions. The sensors show a large linear range of arond 10 Oe, a good thermal stability, a low hysteresis and a low area footprint, making them superior to conventional MR sensors.

MA 55.58 Fri 10:30 P2

Study of material parameters of YIG films with ferromagnetic resonance techniques — •Stefan Klingler[1], Andrés Conca[1], Andrii Chumak[1], Burkard Hillebrands[1], Behrouz Khodadadi[2], and Tim Mewes[2] — [1]FB Physik und Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Center for Materials for Information Technology, University of Alabama, Al, USA

The developement of spintronics is aiming to a replacement of the electron charge as information carrier. In this emerging field the electron spin is used as information carrier which can be manipulated without current and therefore without the limitations due to heating. In this context the material parameters of YIG are of crucial importance for the application in magnonics and spintronics.

Here, we present measurements of the saturation magnetization M_s and the exchange constant A of liquid phase expitaxy (LPE) grown YIG films. The films were grown on (111) Gadolinium Gallium Garnet (GGG) substrates with a thickness of 0.91, 1.6 and 2.6 μm and a size of 3×3 mm. The YIG samples were investigated with a waveguide ferromagnetic resonance (FMR) setup in a frequency range from 5 to 40 GHz in in-plane and out-of-plane configuration. A and M_s were determined using the first perpendicular standing spin wave modes (PSSW) and the method of Schreiber and Frait [1]. The results for both configurations are compared and thereby an angular dependence was detected.

[1] Phys. Rev. B, **54**, 6473 (1996)

MA 55.59 Fri 10:30 P2

Magnetic correlations in an Fe monolayer on Rh(001) — András Deák and •László Szunyogh — Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary

Motivated by recent experiment of Takada et al. [1] we studied the magnetic thin film system consisting of a monolayer of Fe deposited on a Rh(001) surface using a classical spin Hamiltonian with parameters obtained from ab initio calculations. The ground state magnetic configuration is estimated using the mean field spin susceptibility and zero-temperature Landau–Lifshitz–Gilbert spin dynamics simulations. We find that model parameters obtained from a ferromagnetic and a disordered local moment reference state result in significantly different configurations, but both show strong frustration and a sensitive dependence on layer relaxations. Our simulations lead to a complex spin-structure different as proposed from SP-STM results, which might be attributed to the influence of multiple-spin interactions missing from our model.

[1] M. Takada, P. L. Gastelois, M. Przybylski, J. Kirschner: A complex magnetic structure of ultrathin Fe films on Rh (001) surfaces J. Magn. Magn. Mater. 329, 95 (2013)

MA 55.60 Fri 10:30 P2

Growth modes and epitaxy of FeAl thin films on a-cut sapphire prepared by ion beam assisted and pulsed laser deposition — •Xiang Yao[1], Ulf Wiedwald[1,2], Moritz Trautvetter[1], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm, Germany — [2]Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany

FeAl in the B2 phase shows paramagnetism. Thin films prepared at ambient temperature, however, usually exhibit the A2 phase, accompanied by ferromagnetism. We investigate this structural phase transition by subsequent annealing in highly textured films. FeAl thin films are grown on a-cut Al_2O_3 substrates using ion beam assisted sputter deposition (IBAD) and pulsed laser deposition (PLD) at 300K. In all cases, a strong [110] out-of-plane texture exists while in-plane orientations differ significantly as revealed by XRD pole figures. IBAD-grown films possess at least three in-plane orientations while PLD-grown films show high quality epitaxial relation with Al_2O_3 substrate. The formation of the two configurations is attributed to the existence of an intermediate metastable crystalline orientation, as concluded from the non-assisted sputter deposition at elevated temperatures. Magnetic properties were tracked by SQUID-magnetometry. For IBAD-grown films, we find an abrupt transition to paramagnetic behavior at 300 K after annealing at $T_A = 300°C$ for 1h while PLD-grown films show a gradual decrease for T_A up to 500°C. We thank the Baden-Württemberg Stiftung for financial support.

MA 55.61 Fri 10:30 P2

Cubic magnetocrystalline anisotropies in ultrathin epitaxial magnetite films on MgO(001) — •Andreas Krampf[1], Nico Pathé[1], Tobias Schemme[1], Timo Kuschel[2], and Joachim Wollschläger[1] — [1]Department of Physiys, Osnabrück University, Germany — [2]Department of Physics, Bielefeld University, Germany

Ultrathin films of magnetite (Fe_3O_4, thickness 10 nm−100 nm) are deposited on lattice matched MgO(001) substrates either by reactive molecular beam epitaxy (RMBE, Fe evaporation in molecular oxygen atmosphere) or by oxidation of previously deposited ultrathin epitaxial Fe films. Both the structure and stoichiometry of the films have been controlled by surface sensitive and bulk sensitive techniques while magnetic properties are characterized by MOKE. In both cases, the magnetite films show in-plane magnetization due to the shape anisotropy. In addition, the easy axes point in Fe_3O_4<110> directions as determined from the coercive fields for different crystallographic directions. This result is in agreement with the well-known easy axes <111> of bulk magnetite if projected on the planar magnetite film.

Alternatively, magnetite films are formed via a two-step growth process. First, Fe films are epitaxially grown. Thereafter, Fe_3O_4 has been deposited by RMBE. The result of this procedure is that the Fe film is completely consumed during growth of the additional magnetite film. The entire film has Fe_3O_4 structure. Surprisingly, the coercive fields are drastically enhanced and the easy axes are rotated by 45° so that they point into Fe_3O_4<100> directions. The mechanism of this effect

is still under discussion.

MA 55.62 Fri 10:30 P2

Preparation and characterisation of TiN thin films — •Alessia Niesen[1], Manuel Glas[1], Daniel Ebke[2], Jan Schmalhorst[1], 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

The preparation of TiN thin films was investigated. The thin films were prepared by RF magnetron sputtering in an UHV sputtering system. To achieve epitaxial (001)-oriented thin films, MgO (001) and SiO_2 (001) substrates were used. During the deposition, the substrate temperature ranged between room temperature and 900°C. X-ray diffraction (XRD) and reflection (XRR) measurements were carried out to determine the crystallographic and surface properties. In addition, atomic force measurements (AFM) were performed to verify the XRR data. Samples deposited on MgO substrate showed a crystalline ordering over the full deposition temperature range, whereas no visible crystallinity was seen for thin films sputtered on SiO_2 substrates. The surface roughness decreases with increasing deposition temperature for samples on MgO. Furthermore the out-of-plane lattice constant and the resistivity reached the theoretical predicted values of 4.242 Å and 20 $\mu\Omega$cm (300 K) with increasing deposition temperature. The in-situ deposition on heated substrate will be compared to an ex-situ annealing process. Finally, the suitability of TiN as seed layer for ferromagnetic materials like Iron and Heusler compounds, e. g. Co_2FeAl or $Mn_{3-x}Ga$, will be discussed.

MA 55.63 Fri 10:30 P2

Ferromagnetic resonance of perpendicular magnetic anisotropy MgO/CoFeB based tri-layers — •Yuriy Aleksandrov[1,4], Ciaran Fowley[1], Kerstin Bernert[1,4], Volker Sluka[1], Ewa Kowalska[1,4], Michael Farle[2], Jürgen Lindner[1], Berthold Ocker[3], Jürgen Fassbender[1,4], and Alina M. Deac Deac[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [2]Universität Duisburg-Essen Fakultät für Physik Experimentalphysik - AG Farle Lotharstr. 1 47057, Duisburg, Germany — [3]Singulus Technologies AG, Hanauer Landstrasse 103, 63796 Kahl am Main, Germany — [4]Institute for Physics of Solids, TU Dresden, Zellescher Weg 16, 01069 Dresden, Germany

In this report we use the ferromagnetic resonance technique to investigate the magnetic properties of a CoFeB layer sandwiched by Ta and MgO layers. Samples were annealed in N2 environment for 30 minutes at temperatures between 150 and 250°C in steps of 50°C. FMR measurements are performed at room temperature using a microwave cavity. Thin films are also investigated by standard magnetometry measurements in a SQUID/VSM and also by the extraordinary Hall effect to extract the saturation magnetization and effective anisotropy. Through FMR we are able to simultaneously extract the out-of-plane anisotropy, the effective magnetization and the damping co-efficient, as a function of annealing temperature. Our results show that post-annealing systematically shifts the magnetic easy axis from in-plane to out-of-plane direction. As the annealing temperature is increased the effective magnetization also increases.

MA 55.64 Fri 10:30 P2

Optimization of the growth of $Ni_{81}Fe_{19}$ and $Co_{40}Fe_{40}B_{20}$ thin films for an all-optical characterization of micron-sized elliptical elements — •Ana Ruiz-Calaforra[1], Thomas Brächer[1,2], Tobias Fischer[1], Andres Conca[1], Britta Leven[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Gottlieb-Daimler-Strasse 47, 67663 Kaiserslautern, Germany

The optimization of the growth of thin ferromagnetic films is decisive for their future application in spintronic devices. Magnetic properties such as the damping or the spin polarization, which have a large impact on the operation efficiency of these devices, depend strongly on the metallic layers which compose them. We present an optimization of the growth of $Ni_{81}Fe_{19}$ and $Co_{40}Fe_{40}B_{20}$ thin films with different underlayers, aiming for a smooth topography, a controlled magnetic anisotropy and magnetic softness and a large magneto-optical signal. By structuring of micron-sized elliptical elements out of the films, the influence of the shape anisotropy and the magnetic anisotropy of the films on the overall magnetic anisotropy has been studied.

Financial support by the DFG-funding of the Excellence Initiative (GSC 266), by the state Rhineland-Palatinate (MBWWK and MWKEL) and by the European Regional Development Fund (ERDF) in the frame of the Spintronic Technology Platform (STeP) is gratefully acknowledged.

MA 55.65 Fri 10:30 P2

Relation between spin and orbital magnetism in excited states of ferromagnetic materials — •Leonid Sandratskii — Max Planck Institute of Microstructure Physics, Halle, Germany

Modern experiments are able to disentangle the time dynamics and temperature dependences of the atomic spin and orbital moments. The results appear to be strongly system dependent. The properties of the orbital moments are closely connected with the properties of the magnetic anisotropy that is the physical quantity of enormous practical importance. And again the experiments on the temperature dependence of the magnetic anisotropy of the itinerant-electron magnets show strongly system dependent behavior and the absence of any universal behavior. By studying the properties of excited states of Fe, Co, CoPd, FePt films and uncapped and capped Co/Pd(001) we shed the light on the origin of the diversity of behavior.

MA 55.66 Fri 10:30 P2

Time Resolved Spin Seebeck Effect Experiments as a Probe of Magnon-Phonon Thermalization Time — Niklas Roschewsky[1], Michael Schreier[1], Akashdeep Kamra[1,2], Felix Schade[1], •Kathrin Ganzhorn[1], Sibylle Meyer[1], Hans Huebl[1], Stephan Gepraegs[1], Rudolf Gross[1,3], and Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Kavli Institut of Nanoscience, Delft University of Technology, Delft, The Netherlands — [3]Physik-Department, TU München, Garching, Germany

We investigate magnon-phonon interaction times in the ferrimagnetic insulator yttrium iron garnet by means of time-resolved spin Seebeck effect experiments at room temperature [1]. We use an intensity modulated laser beam to dynamically generate a temperature gradient across yttrium iron garnet/normal metal thin film stacks, and record the ensuing spin Seebeck voltage. Our measurements show no intrinsic frequency dependence of the spin Seebeck voltage up to laser modulation frequencies corresponding to timescales of a few nanoseconds. These results put an upper limit to the magnon-phonon interaction time constant relevant for the spin Seebeck effect at room temperature, suggesting that small wavenumber k magnons, with magnon-phonon interaction times of a few hundred nanoseconds, do not play an important role for the spin Seebeck effect in these structures.

This work is supported by the DFG via SPP 1538 and the German Excellence Initiative via the Nanosystems Initiative Munich (NIM).

[1] N. Roschewsky *et al.*, arXiv 1309:3986.

MA 55.67 Fri 10:30 P2

Dependence of Ferromagnetic Resonance Behaviour on Chemical Disorder in $Fe_{60}Al_{40}$ Thin Films — •Rantej Bali[1], Tobias Schneider[1,3], Jakob Gollwitzer[1], Simon Rupp[1], Falk Meutzner[1,2], Richard Boucher[2], Kay Potzger[1], Jürgen Bauch[2], Jürgen Fassbender[1,3], Kilian Lenz[1], and Jürgen Lindner[1] — [1]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]Institut für Werkstoffwissenschaft, Technische Universität Dresden, 01069 Dresden, Germany — [3]Institut für Festkörperphysik, Technische Universität Dresden, 01069 Dresden, Germany

We report on the influence of chemical disorder in $Fe_{60}Al_{40}$ thin films on their ferromagnetic resonance. Chemical disorder leads to increased nearest neighbour Fe-Fe magnetic interactions and plays a crucial role in inducing ferromagnetism. The saturation magnetization increases from 20 kAm^{-1} for the chemically ordered film to 780 kAm^{-1} for disordered films. Disorder was induced by irradiation of Ne^+ ions, and the depth-distribution of disorder was controlled by adjusting the ion-energy and -fluence. For moments aligned within the film plane, the resonant linewidth decreases with increasing ion-energy in the range from 2.5 to 30 keV, for a fixed ion-fluence. In-plane magnetic anisotropy is negligible in all cases. The linewidths for in-plane moment alignment are much larger than in materials that do not exhibit disorder induced ferromagnetism. These results may be explained by enhanced two-magnon scattering due to the presence of random defects, and help in preparing thin films with tailored spin-wave dynamic properties.

MA 55.68 Fri 10:30 P2

Magneto-Crystalline Anisotropy of X-Ray Magnetic Linear

Dichroism in Reflection and Fluorescence at the Fe 2p1/2, 2p3/2 Edges — •Christine Jansing[1], Marc Tesch[1], Markus Gilbert[1], Hans-Christoph Mertins[1], Andreas Gaupp[2,1], Dominik Legut[3], Peter Oppeneer[4], Daniel Bürgler[5], Claus Schneider[5,6], and Ulf Berges[7] — [1]FH Münster, Stegerwaldstr. 39, D-48565 Steinfurt — [2]HZB, D-12489 Berlin — [3]Nanotech. Centre, Ostrava, Czech Rep. — [4]Depart. of Physics, Uppsala Uni., Uppsala, Sweden — [5]FZ Jülich, PGI-6, D-52425 Jülich — [6]Fak. f. Physik+CeNIDE, Uni Duisburg-Essen, D-47048 Duisburg — [7]DELTA, D-44227 Dortmund

We present first experimental results on the magneto-crystalline anisotropy of X-ray magnetic linear dichroism signals detected on single crystalline bcc Fe films at the 2p edge by measurements in reflection (XMLD-R) and fluorescence (XMLD-F) using linearly polarized undulator radiation at BESSY and DELTA. First XMLD measurements at the Fe 2p edge [1] used total electron yield (TEY) detection. In contrast to TEY XMLD-R and XMLD-F spectroscopy is unaffected by the applied magnetic field and hence allows also for the investigation of buried layers. The XMLD-R and XMLD-F spectra depend on the orientation of the crystal axes, i.e. the magnetic easy and medium axes, with respect to the polarization vector of the light and show strong changes of up to 100 percent. Comparing the experimental results with our ab initio calculations allows to distinguish between competing models of the electronic band structure.

[1] F. Nolting, D. Legut, J. Rusz et al., Phys. Rev. B 82,184415(2010)

MA 55.69 Fri 10:30 P2

Thin Films of *M*-Type Magnetoelectric Hexaferrites — •Bastian Stibbe[1], Stephan Geprägs[1], Matthias Opel[1], and Rudolf Gross[1,2] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik Department, TU München, Germany

Room-temperature magnetoelectric materials, which exhibit a cross-coupling between electric and magnetic order parameters, have attracted widespread interest over the last years, since they provide new opportunities in designing low-power spintronic devices. Among this class of materials, magnetoelectric hexaferrites are promising candidates, since they show large magnetoelectric effects at room temperature and low magnetic fields [1]. In particular, large electric field-induced changes of the magnetization were reported in the polycrystalline *M*-type hexaferrite $SrCo_2Ti_2Fe_8O_{19}$ [2].

Here, we report on the deposition of epitaxial $SrCo_2Ti_2Fe_8O_{19}$ thin films on Al_2O_3 (0001) single crystalline substrates by laser-MBE. To optimize the structural and magnetic properties, a series of $SrCo_2Ti_2Fe_8O_{19}$ thin films was fabricated varying the substrate temperature, the oxygen partial pressure as well as the laser fluence of the ablation process. The thin films are analyzed using high-resolution x-ray diffractometry, atomic-force microscopy, and SQUID magnetometry. Furthermore, converse magnetoelectric effects in terms of electric-field induced changes of the magnetization are discussed.

[1] T. Kimura, Annu. Rev. Condens. Matter Phys. **3**, 93 (2012).
[2] L. Wang *et al.*, Sci. Rep. **2**, 223 (2012).

MA 55.70 Fri 10:30 P2

Spin-liquid phase and order-by-disorder on the frustrated swedenborgite-lattice — •Stefan Buhrandt[1] and Lars Fritz[2] — [1]Institut für theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany — [2]Institute for Theoretical Physics, Utrecht University, Leuvenlaan 4, 3584 CE Utrecht, The Netherlands

Geometrical frustration is the phenomenon that not all antiferromagnetic exchange interactions in a system can be completely satisfied simultaneously due to the geometry of the underlying lattice. A lattice exhibiting a very unusual and interesting exchange topology is formed by the magnetic ions in compounds of the swedenborgite family, where the magnetic ions reside on alternating stacked triangular and Kagomé layers. While in general there are four distinct next neighbor exchange interactions allowed by symmetry on this lattice, a simplified model with only two distinct interactions, J_1, describing the exchange inside the Kagomé layers and J_2, accounting for the exchange between the Kagomé and triangular layers, is widely used and has proven to be sufficient to reproduce experimental findings. Depending on the ratio J_2/J_1, the ground state of the model is either unique or highly degenerated. In the latter case, coplanar ground states are eventually selected by an entropic order-by-disorder transition at low temperatures. The presence of soft modes in these ground states reduces the specific heat per spin in the limit $T \to 0$ from 1 to 15/16. Additionally, we find a broad spin-liquid regime over a wide range of parameters and temperatures, which might persist even in the presence of small additional interactions.

MA 55.71 Fri 10:30 P2

The mechanisms of the Dy Grain Boundary Diffusion Process in sintered NdFeB permanent magnets — •Konrad Löwe[1], Christoph Brombacher[2], Matthias Katter[2], and Oliver Gutfleisch[1] — [1]TU Darmstadt, Materials Science, 64287 Darmstadt, Germany — [2]VACUUMSCHMELZE GmbH & Co. KG, 63450 Hanau, Germany

We investigated the mechanisms of Dy diffusion in Nd-Fe-B permanent magnets. At optimum annealing conditions the Dy processed magnets yield a total coercivity increase of 4.5 kOe and a roughly constant remanence. The switching field distribution along the diffusion direction was measured with a hall probe. For an application of 0.3 wt% Dy and annealing at 900°C an increased coercivity was found up to a depth of about 3 mm. Microstructure analysis by WDX and TEM EDX revealed an enhanced Dy concentration in the surface region of the individual Nd-Fe-B grains. The Dy concentration in these so-called "shells" decreased exponentially from 6.0 at% at the surface of the magnet to about 1.8 at% after a diffusion depth of 0.4 mm. The mechanism of Dy-shell formation was reasoned to be melting/solidification of a rare earth rich intermediate phase during high-temperature annealing. This assumption is based on the fact that a constant Dy concentration over the width of a shell was found. With EBSD no orientation difference between the Nd-Fe-B grains and the surrounding shells has been found, which points to an epitaxial solidification of the melt on the grains.

MA 55.72 Fri 10:30 P2

Analysis of Magnetic Flux in non–oriented Electrical Sheet — •Anna Brunner, Rudolf Schäfer, and Ludwig Schultz — IFW Dresden, Institut for Metallic Materials, Dpt. Magnetic Microstructures, Helmholtzstr. 20, D-01069 Dresden

Although non–oriented bulk magnetic material like electrical steel is traditionally used in motors, generators or other inductive applications, the mechanisms of flux propagation are so far unexplored. In this presentation we adapt a quasi domain model to describe flux propagation, especial across grain boundaries which are in general obstacles for the magnet flux. We wrote a program to calculate the quasi–domain combination with the smallest grain boundary charge for a given grain orientation towards a grain boundary. The grain orientation of the non–oriented iron–silicon samples was determined by EBSD (Electron BackScatter Diffraction). The domain movement at charged and uncharged grain boundary areas was observed with Kerr–microscopy. The examinations are exemplified at three grain boundaries (one between two grains of slight misorientation with respect to the surface, another one between two grains of strong misorientation with respect to the surface and a last one between a strongly and a slightly misoriented grain).

MA 55.73 Fri 10:30 P2

structure and magnetocaloric effect of Gd-based compound — •Guangcun Shan[1,2], JiLiang ZHANG[1], and Chan-Hung SHEK[1] — [1]Department of Physics and Materials Science, City University of Hong Kong, Hong Kong — [2]Max-Planck-Institut für Chemische Physik fester Stoffe

Gd-based compound was synthesized successfully, and the compound shows good soft magnetic behavior at room temperature with a Curie temperature ~ 350 K. The compound exhibits non Curie-Weiss behavior in a large temperature range above Curie temperature, and slightly enhanced Gd moment at low temperature. The elevated Curie temperature and slightly enhanced Gd magnetic moment were interpreted using Ruderman-Kittel-Kasuya-Yosida model, based on measured electronic structure and density functional theory (DFT) simulation results. The magnetocaloric effect was also measured in terms of the maximum magnetic entropy change of -4.3 J*Kg-1K-1 at 50 kOe and -2.3 J*Kg-1K-1 at 20 kOe.

MA 55.74 Fri 10:30 P2

Multiferroic $Ni_3V_2O_8$ measured in THz range at low temperatures and in high magnetic fields — •Malte Langenbach[1], Komalavalli Thirunavukkuarasu[1], Iván Cámara Mayorga[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 report on transmission measurements on the Kagomé-staircase compound $Ni_3V_2O_8$. The triangle-based lattice gives rise to frustration of the short-range antiferromagnetic couplings. This causes a rich phase diagram at low temperatures [1]. Below T_N=9.8 K, an 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 [2]. 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] M. Kenzelmann et al., Phys. Rev. B 74, 014429 (2006)
[2] G. Lawes et al., Phys. Rev. Lett. 95, 087205 (2005)

MA 55.75 Fri 10:30 P2

Magnetic and orbital order in the system $Fe_{1-x}Cu_xCr_2S_4$ ($0 \le x \le 0.9$) studied by Mössbauer spectroscopy — •Elaheh Sadrollahi[1], Mathias Kraken[1], Nicole Christiane Schmidt[1], F. Jochen Litterst[1], Vladimir Tsurkan[2], Alois Loidl[2], and G. Michael Kalvius[3] — [1]IPKM, Technische Universität Braunschweig — [2]Experimentalphysik V, Universität Augsburg — [3]Physik Department, Technische Universität München

Cr based thiospinels of the type $Fe_{1-x}Cu_xCr_2S_4$ ($0 \le x \le 1$) have attracted considerable attention due to a variety of interesting electronic and magnetic properties. We have performed a systematic Mössbauer spectroscopic study of the spinel system $Fe_{1-x}Cu_xCr_2S_4$ with $0 \le x \le 0.9$ between 4 and 300 K. We could follow the gradual transformation from Fe^{+2} to Fe^{+3} in dependence on Cu doping and the related changes in magnetic ordering.

At low temperatures we find for low Cu doping changes in nuclear electric quadrupole interaction due to changes in the crystalline electric field connected with orbital ordering. Dynamic line broadening related with magnetic orbital dynamics will be discussed.

MA 55.76 Fri 10:30 P2

Magnetic property of Mixed valent Sodium Sequioxide (Na2O3) — •Shivakumara Giriyapura, Sergiy Medvediev, Martin Jansen, and Claudia Felser — MPI-CPFS, 01187, Dresden

It is well-known that compounds containing mixed diatomic oxygen species (superoxide (O2-) is magnetic and peroxide (O22-) diamagnetic) can be stabilized in different forms of A2O2 , A2O3, AO2 and AO2-x [1,3] (A = alkaline metals). Consequently, it is been realized that alkali superoxides (A+O2-) containing magnetic diatomic O2-ions behave like strongly correlated transition metal compounds, where the displacive Jahn-Teller distortion lifts the degeneracy and leads to the reorientation of diatomic anions (O2-) with corresponding orbital ordering (OO) [2][3]. Similarly, mixed valent A4O6 reveals a mixture of superoxide O2- and peroxide O22- with different valency which can lead to a charge ordered state in the lattice. Charge order (CO) is known to be in competition with superconductivity. Accordingly, its been synthesized the Sodium sesquioxide (Na2O3) and discussed the structural and magnetic studies of this compound in comparison with the magnetic end member NaO2 and rest of the alkali sesquioxide(A4O6. [1] W. Hesse, M. Jansen and W. Schnick, Prog. Solid St. Chem. Vol. 19, pp. 47-110. 1989.[2] S. Riyadi, B. Zhang, R. A de Groot, A. Caretta, P.H.M. van Loosdrecht, T. T. M. Palstra and G.R.Blake, Phys. Rev. Lett. 108, (2012) 217206.[3] S.Riyadi, S.Giriyapura, R.A. de Groot, A.Caretta, P.H. M. van Loosdrecht, T. T. M. Palstra, and G. R. Blake. Chem. Mater. 2011, 23, 1578*1586.

MA 55.77 Fri 10:30 P2

Enhancement of Faraday Rotation in BiIG optical resonators — •Felix Spitzer[1], Sören Kreinberg[1], Lars E. Kreilkamp[1], Ilya Akimov[1,2], Vladimir I. Belotelov[2,3,4], Mohammed Nur-E-Alam[5], Mikhail Vasiliev[5], Kamal Alameh[5], and Manfred Bayer[1] — [1]Experimentelle Physik II, TU Dortmund, D-44221 Dortmund, Germany — [2]Ioffe Physical-Technical Institute, Russia Academy of Sciences, 119991 Moscow, Russia — [3]Russian Quantum Center, 143025 Moscow, Russia — [4]Prokhorov General Physics Institute, Russian Academy of Sciences, 119991 Moscow, Russia — [5]Electron Science Research Institute, Edith Cowan University, 6027 Joondalup, WA, Australia

We study the spectral dependence of Faraday Rotation in μm-thin bismuth iron garnet (BiIG) films under illumination by a white light source.

By applying a thin layer of Ag the Faraday Rotation can be enhanced due to the longer optical path length within the sample. With a silver layer on both sides, the sample acts as an optical resonator thus leading to resonant behavior of the Faraday Rotation and its enhancement by up to one order of magnitude depending on the parameters of the structure

MA 55.78 Fri 10:30 P2

In-situ Polarised Neutron Reflectometry during Thin Film Growth by DC Magnetron Sputtering — •S. Mayr[1], W. Kreuzpaintner[1], B. Wiedemann[1], A. Schmehl[2], T. Mairoser[2], A. Herrnberger[2], J.-F. Moulin[3], J. Stahn[4], P. Korelis[4], M. Haese-Seiller[3], M. Pomm[3], A. Paul[1], P. Böni[1], and J. Mannhart[5] — [1]Technische Universität München — [2]Universität Augsburg — [3]Helmholtz Zentrum Geesthacht — [4]Paul Scherrer Institut Villigen — [5]Max Planck Institut Stuttgart

Since thin magnetic layers are used in many magneto-electronic devices the understanding of their texture and the coupling between them is essential to improve functionality. As these parameters are likely to change during the deposition process, in-situ polarised neutron reflectometry (PNR) is used to monitor the development of the structural and magnetic properties of thin films while they are grown. We routinely carry out in-situ PNR measurements using either the horizontal Time-of-Flight reflectometers REFSANS at FRM II or AMOR at PSI with a specially designed sputtering chamber as sample environment combined with modern neutron optical elements. In this contribution, the epitaxial growth of Fe and Cr on a Cu(100)/Si(100) substrate and the observed onset and evolution of the magnetic properties as a function of film thickness will be presented. Initially, after each monolayer deposition step, the reflectivity of polarised neutrons was measured during a short period of time. After approximately 100 Å, the deposition process was adapted and Fe/Cr-bilayers were grown to investigate the evolution of exchange coupling effects in a Fe/Cr heterostructure.

MA 55.79 Fri 10:30 P2

Conventional and inverse magnetocaloric effects at magnetostructural transitions in Mn-based compounds — •Franziska Scheibel[1], Öznur Cakir[2], Atakan Tekgül[3], Mehmet Acet[1], and Michael Farle[1] — [1]Faculty of Physics and CENIDE, Universität Duisburg-Essen, D-47048 Duisburg, Germany — [2]Physics Department, Yildiz Technical University, Davutpasa, Istanbul, Turkey — [3]Physics Department, Akdeniz University, Antalya, Turkey

One key factor for efficient magnetic refrigeration is reversibility in the temperature-change on applying and removing the external magnetic field to the active magnetic refrigeration material. At magnetostructural transitions, where large entropy changes can occur, this occurs only in systems with sufficiently narrow thermal hysteresis at the transition. To understand how reversibility is related to hysteresis, entropy-changes and corresponding adiabatic temperature-changes are studied in Mn-rich Heusler alloys, anti-perovskites, and pnictides. We study the magnetization and the adiabatic temperature-change in the temperature range $5 \le T \le 380$ K in magnetic fields up to 5 T using a SQUID magnetometer and a calorimeter, respectively. The structural properties are further investigated by x-ray diffraction. The results indicate that the occurrence of long range ferromagnetism in any one of the phases below or above the magnetostructural transition in the systems mentioned above is unfavorable for a reversible temperature change. In contrast, the presence of ferrimagnetism or enhanced paramagnetism leads to a narrow thermal hysteresis of the transition.

Work supported by the Deutsche Forschungsgemeinschaft (SPP 1599)

MA 55.80 Fri 10:30 P2

High Resolution Imaging of Spin Current-driven Magnetization Manipulation in Nanoscale Structures using SEMPA — •Pascal Krautscheid, Robert M. Reeve, and Mathias Kläui — Institut für Physik, Johannes Gutenberg-Universität, 55128 Mainz, Germany

The utilization of the electron spin degree of freedom, instead of its charge, was proposed to manipulate the magnetic state of a system including the domain wall spin configuration. The interaction between a spin current and the magnetic moments of a system can be described by the implicit Landau-Lifshitz-Gilbert equation [1]. However, the origin of the non-adiabatic spin torque and its relation to the damping is not well understood and several theoretical predictions exist, which can only be distinguished by experiments. We consider a magnetic vortex state within a permalloy-disk and measure the vortex core displacement to gain information about the non-adiabatic spin torque

[2]. By altering the damping, e.g. using a rare earth element as a dopant [3] the relation between the damping and the non-adiabatic spin torque can be derived. The vectorial magnetization information within the plane of our nanoscale structure is measured by a scanning electron microscope with polarization analysis, which offers the necessary high-resolution magnetic imaging.

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MA 55.81 Fri 10:30 P2

magnetic properties of (Fe,Co)2B alloy with uniaxial magnetocrystalline anisotropy — •Hong Jian[1,2], Konstantin Skokov[1], Michael Kuzmin[1], and Oliver Gutfleisch[1] — [1]Department of Materials Science, TU Darmstadt, Petersenstr. 23, 64287 Darmstadt, Germany — [2]Department of Materials Science and Engineering, Zhejiang University, Zheda Road. 38, 310027 Hangzhou, China

The high cost of rare earth elements has driven scientists to search for rare-earth-free magnets with high magnetocrystalline anisotropy. Uniaxial magnetocrystalline anisotropy in the (Fe,Co)2B system has been reported, where K1 of ~410 kJ/m3 at room temperature was obtained in (Fe0.7Co0.3)2B. However, the possibilities for practical application of this alloy system are by no means explored. Furthermore, (Fe,Co)2B system also provides a good model to study the origin of magnetocrystalline anisotropy in 3d elements. In this work, we investigated the intrinsic magnetic properties of (Fe,Co)2B alloy on single crystal and also extended measurements to high temperatures up to 873K. It is expected that this alloy can be used as a semi-hard magnet.

MA 55.82 Fri 10:30 P2

Electronic strcuture, magnetism and chemical bonding in hydrides of transition metal — •Abdesalem Houari[1] and Volker Eyert[2] — [1]Theoretical Ḧyics Laboratory, Dpt. Phyics, University of Bejaia, Bejaia, Algeria — [2]Center for Electronic Correlations and Magnetism, Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

Based on density functional theory calculations, we present an *ab initio* study of the structural stability of the palladium-hydrogen (Pd-H) and platinum-hydrogen systems. Here, we first investigate two ideal stoichiometries: the monohydride Pd $(Pt)_1H_1$ and dihydride Pd $(Pt)_1H_2$. The formers was considered in different types of structures (faces centered cubic *fcc*-rocksalt, *fcc*-zincblende, and hexagonal symmetry), while the latters was considered in two cubic ones which are fluorite and pyrite. Energy versus volume calculations were carried out in all structures and theoretical equilibrium properties (lattice constant, bulk modulus ...etc) are thus obtained. By evaluating and comparing total energies, the ground state crystal structure is found, and it agree with the experimental finding. While the monohydride is energetically more stable than dihydride in Pd-H, the inverse is expected in Pt-H. On the other hand, the whole systems are found to be non magnetic at theoretical equilibrium. We have studied some experimentally synthesized vacancy-defect phase such as Pd_3H_4 compound. The obtained results (equilibrium lattice constant) are in perfect agreement with experimental

MA 55.83 Fri 10:30 P2

Magnetic properties in hydrogenated Li doped ZnO microwires — •Israel Lorite[1], Carlos Ivan Zalandazini[2], Silvia Perez[2], and Pablo Esquinazi[1] — [1]Division of Superconductivity and Magnetism, Institute for experimental Physics II, Fakultät für Physik und Geowissenschaften, Linnéstrasse 5, 04103 Leipzig, Germany — [2]Laboratorio de Física del Sólido, Dpto. de Física, FCEyT, Universidad Nacional de Tucumán, 4000 Tucumán, Argentina

We have studied the magneto-transport properties of ZnO and Li doped ZnO treated with H plasma at room temperature, ZH and ZLH respectively. After plasma treatment a negative magnetoresistance, in perpendicular configuration, of ~1% and ~3.5% at 8T applied field is measured at 10K for ZH and ZLH, respectively. The magneto resistance can be well explained by a semi empirical model taking into account local magnetic moments and the s-d exchange interaction. A comparison with parallel configuration indicates possible anisotropy in the magneto resistance indicative of the appearance of magnetic order, further observed by SQUID. Finally, it has been found a minimum of magneto-resistance at 125 K for ZLH sample. It can be interpreted by means of two different parallel contributions: due to the VRH mechanism, below 125 K, and due to exchange interaction contribution above 125 K.

MA 55.84 Fri 10:30 P2

Preparation and structural and magnetic characterisation of transition metal-doped ZnO thin films. — •Vasantha Venkataraman[1], Verena Ney[1], Katharina Ollefs[2], Fabrice Wilhelm[2], Andrei Rogalev[2], and Andreas Ney[1] — [1]Division of Solid State Physics, Johannes Kepler University, Linz, Austria — [2]European Synchrotron Radiation Facility (ESRF), Grenoble, France

Numerous experimental studies have surfaced involving doping of ZnO thin films with transition metals (TM:ZnO). Though neither Cu, nor its oxides are ferromagnetic, reports of ferromagnetic Cu:ZnO can be found [1]. By DC reactive magnetron sputter deposition, we have prepared Cu:ZnO films on c-plane sapphire. By varying the proportions of the reactant (O_2) and carrier (Ar) gases, we have a series of samples and have found three separate regimes. The regimes show a marked difference in terms of their apparent colour. Using x-ray absorption spectroscopy at the Cu-K edge, we have probed the series in order to establish an interrelation between the observed magnetic behavior and the local atomic positioning of dopant Cu atoms and the valence [2]. The XANES point to the oxidation states in the different regimes and XLD in turn indicates the substitution of the Zn atom sites by Cu as being unfavourable. SQUID magnetometry on the series has revealed paramagnetic behavior irrespective of regime.

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[2] J. L. DuBois et al., J. Am. Chem. Soc. 122, 5775 - 5787 (2000)

MA 55.85 Fri 10:30 P2

Adiabatic and dynamic spin-wave spectra in the homogeneous electron gas — •Maximilian Kulke and Arno Schindlmayr — Department Physik, Universität Paderborn, 33095 Paderborn, Germany

Spin-wave spectra of itinerant ferromagnets can be calculated from a variety of ab initio methods, such as the adiabatic frozen-magnon approximation, time-dependent density-functional theory or many-body perturbation theory. A quantitative comparison for real materials is not straightforward, however, because practical implementations of these schemes typically rely on different numerical approximations. To avoid such difficulties and allow a clearer assessment, we study spin waves in the spin-polarized homogeneous electron gas, where an almost completely analytic evaluation of these methods is possible. Within the adiabatic approximation we seek self-consistent solutions of the static Kohn-Sham equations with a constraint that enforces a noncollinear spin-spiral configuration with a given wave vector. As an alternative, we obtain the spin-wave dispersion from the poles of the dynamic transverse spin susceptibility within time-dependent density-functional theory. The same exchange-correlation functional, the (adiabatic) local-spin-density approximation, is used in both cases. Besides a comparison of the calculated spin-wave energies over a large range of wave vectors, we specifically focus on the spin-wave stiffness, which corresponds to the leading parabolic dispersion coefficient in the limit of long wave lengths.

MA 55.86 Fri 10:30 P2

Electronic strucure and finite-temperature magnetic properties of FeRh — •Sergiy Mankovsky[1], Svitlana Polesya[1], Jan Minar[1], Catherine Bordel[2], Cristian Back[3], and Hubert Ebert[1] — [1]Dept. Chemie/Physikalische Chemie, Universität München, D-81377 München, Deutschland — [2]Department of Physics, University of California, Berkeley, California 94720, USA — [3]Department of Physics, Universität Regensburg, 93040 Regensburg, Deutschland

The temperature-induced magnetic phase transitions in FeRh, AFM→FM ($\approx 340K$) and FM→PM ($\approx 670K$) have been investigated by Density Functional Theory (DFT) electronic structure calculations using the fully relativistic Korringa-Kohn-Rostoker Green function (KKR-GF) method. First-principles exchange coupling parameters, J_{ij}, have been used to determine the temperature dependent magnetic properties of FeRh within Monte Carlo simulations based on Heisenberg model. The Gilbert damping parameter calculated for the FM state as a function of temperature is in a good agreement with the experimental results. Separate calculations with temperature-induced structure disorder only as well as structure and magnetic disorder accounting for together allow to make a conclusion about the role of spin fluctuations for the Gilbert damping. The temperature dependent magnetic anisotropy has been investigated for FeRh films grown on two different substrates. The calculations demonstrate the strain induced spin-reorientation transition for both FeRh films across the

AFM-FM phase transition, that is in a good agreement with experiment.

MA 55.87 Fri 10:30 P2

Dzyaloshinskii-Moriya interaction in the Kondo lattice model — •Kathrin Höfner and Wolfgang Nolting — Institut für Physik, Humboldt-Universität zu Berlin, Germany

In the recent years much research has been focused on magnetic systems with low symmetry or low dimensionality that exhibit interesting non-collinear spin structures.

A popular explanation for these structures is the Dzyaloshinskii-Moriya (DM) interaction, an effective anisotropic and antisymmetric coupling between localized spins. While successful in describing the magnetic properties of various systems, the justification of the interaction itself depends on the specific electronic structure of the considered material.

We therefore relate the DM-interaction to the electronic structure of a multi-band Kondo lattice model. The RKKY formalism is generalized to allow the inclusion of spin-orbit coupling in a non-perturbative manner. We show that this procedure leads to Heisenberg-, Ising-, and Dzyaloshinskii-Moriya-like terms. The obtained exchange integrals and the resulting magnetic structure are discussed.

MA 55.88 Fri 10:30 P2

Dual Boson Approach to Collective Magnetic Excitations in the Hubbard Model — •Friedrich Krien[1], Erik van Loon[2], Hartmut Hafermann[3], Mikhail Katsnelson[2], Alexei Rubtsov[4], and Alexander Lichtenstein[1] — [1]Dep. of Physics, University of Hamburg, Jungiusstrasse 9, 20355 Hamburg, Germany — [2]Institute for Molecules and Materials, Radboud University of Nijmegen, 6525 AJ Nijmegen, The Netherlands — [3]IPhT, CEA, CNRS, 91191 Gif-sur-Yvette, France — [4]Dep. of Physics, Moscow State University, 119992 Moscow, Russia

The recently developed dual boson approach is a generalization of the dual fermion theory to study collective excitations in systems of the extended Hubbard model type.

Here we present the implementation scheme that is currently under testing and development by the authors. We reason why its account of collective excitations is also expected to improve the understanding of such in the simpler Hubbard model. We outline the steps to take full account of charge and magnetic excitations within the extended Hubbard model in the future.

MA 55.89 Fri 10:30 P2

Characterization of epitaxial Ni-Mn-Sn thin films with out-of-plane composition gradient — •Niclas Teichert[1], Lars Helmich[1], Svetlana Klimova[1,2], Anna Behler[3], Christian Behler[3], Anja Waske[3,4], Walid Hetaba[1,5], and Andreas Hütten[1] — [1]Bielefeld University, Department of Physics, Thin Films and Physics of Nanostructures, 33615 Bielefeld, Germany — [2]Saratov State University, Department of Nano- and Biomedical Technology, 410012 Saratov, Russia — [3]IFW Dresden, Institute for Complex Materials, 01069 Dresden, Germany — [4]TU Dresden, Institut für Festkörperphysik, 01062 Dresden, Germany — [5]Vienna University of Technology, Universitäre Service-Einrichtung für Transmissionselektronenmikroskopie (USTEM), Wiedner Hauptstraße 8-10, A-1040 Wien, Austria

Ni-Mn-Sn is a ferromagnetic shape memory alloy and a promising magnetocaloric material. In this study we investigate epitaxial Ni-Mn-Sn thin films with out of plane gradient of e/a from 8.05 to 8.12. The gradient is applied in order to expand the temperature range of the martensitic transition. The films are prepared by magnetron co-sputtering on MgO(001) substrates. The composition gradient is realized by variation of the Sn rate during the sputter process. We see a widening of the transition range without widening of the thermal hysteresis. We compare films with increasing and decreasing e/a from substrate to surface. The applied methods to study the martensitic transition are temperature dependent resistivity and magnetization measurements, X-Ray Diffraction, and Transmission Electron Microscopy.

MA 55.90 Fri 10:30 P2

Zero Field ^{55}Mn NMR study of Ni-Mn-Sn Heusler alloys — •Maria Eleni Belesi[1], Ahmad Omar[1], Sabyasachi Pramanick[2], Subham Majumdar[2], Bernd Büchner[1,3], and Sabine Wurmehl[1,3] — [1]Leibniz Institute for Solid State and Materials Research, Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany — [2]Department of Solid State Physics, Indian Association for the Cultivation of Science, 2A and B Raja S. C. Mullick Road, Jadavpur, Kolkata 700 032, India — [3]Institute for Solid State Physics, TU Dresden, D-01069, Germany

We present a nuclear magnetic resonance (NMR) study of the Heusler alloys $Ni_2Mn_{1+x}Sn_x$, which are known to exhibit shape memory effects, exchange bias, inverse magnetocaloric and giant magnetoresistance in certain stoichiometry regimes. The x=0 member of the family, Ni_2MnSn, is a ferromagnetic Heusler alloy with a Curie temperature of T_C=349 K and cubic $L2_1$ structure. For $0.35 < x < 0.47$ these compounds manifest a structural transition to the so-called martensitic phase, which has lower crystal symmetry than the parent cubic state and is dominated by a complex strained structure. To probe this structure as well as the accompanied modification of the local magnetic properties through the martensitic transition, we perform zero-field ^{55}Mn NMR experiments on $Ni_2Mn_{1+x}Sn_x$ samples prepared by arc melting. These experiments provide local information for the evolution of the structural and magnetic properties with stoichiometry and as we vary the temperature through the martensitic transition.

MA 55.91 Fri 10:30 P2

Thin film synthesis of the semiconducting Heusler compound Fe2TiSi — •Markus Meinert[1], Manuel Patrice Geisler[1], Jan Michael Schmalhorst[1], Günter Reiss[1], and Elke Arenholz[2] — [1]Center for Spinelectronic Materials and Devices, Bielefeld University, Germany — [2]Advanced Light Source, Berkeley, CA, USA

From band structure calculations, Fe_2TiSi is predicted to be a semiconductor with a narrow gap (about 0.3 eV) and a possible use for thermoelectric applications has been pointed out. [1]

We have synthesized $L2_1$ single-phase thin films of Fe_2TiSi on MgO substrates by DC and RF magnetron co-sputter deposition. The films have a resistivity of 1700$\mu\Omega$cm at room temperature, reaching 4700$\mu\Omega$cm at 2K. The carrier density is about $5 \cdot 10^{20}$cm^{-3} independent of temperature. These results are similar to earlier results on the pseudogap system Fe_2VAl. [2] The resistivity follows a logarithmic temperature dependence up to room temperature, which indicates Kondo scattering off magnetic impurities as the governing mechanism.

A band gap of about 0.4 eV is observed in optical absorption spectra and the general shape of the absorption and reflectance curves agrees with density functional theory calculations. Thus, Fe_2TiSi is in fact the first semiconducting full-Heusler compound reported to date.

[1] S. Yabuchi et al., Appl. Phys. Express 6, 025504 (2013). [2] H. Okamura et al., Phys. Rev. Lett. 84, 3674 (2000).

MA 55.92 Fri 10:30 P2

Photoresponse of $La_{0.7}Ce_{0.3}MnO_3$ films revisited – dominating role of the $SrTiO_3$ substrate — •Andreas Thiessen, Elke Beyreuther, and Lukas M. Eng — Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany

Cerium-doped $LaMnO_3$ films, which have been discussed as an electron-doped counterpart to the common hole-doped mixed-valence lanthanum manganites, were analysed regarding their manganese valence, conductivity and magnetoresistance under illumination. While oxygen-reduced $La_{0.7}Ce_{0.3}MnO_3$ films had shown a large photoconductivity effect as well as a light-induced recovery of the metal-insulator transition in the past [Beyreuther et al., PRB 80, 075106 (2009)], whose microscopic origins remained uncertain, the present study finds strong evidence for the determining role of the photoconductive $SrTiO_3$ substrate by the systematic investigation of a broad set of films with varied thickness, oxygen content, and degree of CeO_2 phase segregation.

MA 55.93 Fri 10:30 P2

Growth and magnetic properties of Heusler alloy type Ru2MnZ (Z=Ge, Si) thin films — •Jan Balluff, Markus Meinert, and Günter Reiss — University of Bielefeld

It has been shown by theory and experiment that the Heusler alloy type compounds Ru2MnZ (Z=Ge, Si) show antiferromagnetic phases. Thin films of these alloys were grown to examine their magnetic properties. Due to their antiferromagnetic order they are in particular interesting for many potential applications in the field of spintronics, i.e. using the Exchange Bias. We will show different growth approaches on MgO and thermally oxidized Si substrates. Furthermore, we will discuss magnetic properties of the compounds including the Exchange Bias.

MA 55.94 Fri 10:30 P2

Double Perovskite La_2CoMnO_6 thin films grown by Metalorganic Aerosol Deposition (MAD) — •Sebastian Hühn[1], Markus Jungbauer[1], Sebastian Merten[1], Ricardo Egoavil[2], Jo Verbeeck[2], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Georg-August-Universität, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Electron Microscopy for Materials Science (EMAT) , Groenenborglaan 171, 2020 Antwerp, Belgium

Some ordered double perovskites (DP) with the general formula $A_2BB'O_6$ exhibit halfmetallic-ferrimagnetic behavior with high Curie temperature $T_C > 400\,K$ and 100% spin polarization [1]. Therefore these DP are interesting for room-temperature applications. High B-site ordering is a prerequisite for full saturation magnetization and high T_C. As a proof of concept we show that it is possible to grow highly ordered La_2CoMnO_6 thin films on $SrTiO_3$ (111) by metalorganic aerosol deposition [2], a chemical deposition technique in ambient atmosphere. B-site ordering is confirmed by XRD, TEM-EELS and Raman spectroscopy. The saturation magnetization of $M_{sat} = 6\,\mu_B$/f.u. and Curie point of $T_C = 230\,K$ agree with the values of highly ordered bulk samples. Financial support from EU FP 7, IFOX (interfacing oxides) project is acknowledged.

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MA 55.95 Fri 10:30 P2

Time evolution of laser-induced changes in electric transport of manganites — •Manuel Mchalwat, Bernd Damaschke, Vasily Moshnyaga, Markus Münzenberg, and Konrad Samwer — 1. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Manganites show structural phenomena at a variety of spatial and time scales ranging from nanometers and picoseconds for single polarons up to microns and seconds for the electronic phase separation. Many of these influence physical properties, e. g. the metal-insulator transition, which is accompanied by a change of the crystal structure and believed to be driven by the formation of correlated polarons near the transition temperature.

By exciting the sample near the transition by short laser pulses we induce or destroy the electronic correlations, i. e. the correlated polarons, and investigate their time development by looking at the electronic transport properties, especially the third harmonic contribution, which is sensitive to the density of polarons.

The work has been supported by the DFG through SFB 1073 TP B01 and by Femtolasers.

MA 55.96 Fri 10:30 P2

Detection of ultra-low magnetic fields based on the planar Hall effect in manganite thin films — •Eduard Unger, Camillo Ballani, Markus Jungbauer, Markus Michelmann, Sebastian Hühn, Danny Schwarzbach, and Vasily Moshnyaga — I.Physikalisches Institut, Universität Göttingen

The anisotropic magnetoresistance (AMR) is widely used for sensing of both direction and absolute value of magnetic fields. 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.[1] For a special AMR geometry, called "planar Hall effect", the measured transverse voltage is sensitive to the direction of the sample magnetization, thus allowing one to investigate magnetization processes like rotation and flops of single magnetic domains driven by an applied field H. Magnetization change and, therefore, the field sensitivity of the transverse voltage was observed to be largest close to the coercitive field H_C, which is about several Oe at room temperature for the investigated films. With the goal to achieve low H_C and high AMR ratios yielding a high detectivity of magnetic fields, we have grown thin manganite films ($La_{0.7}Sr_{0.3}MnO_3$ and $La_{0.6}Ba_{0.4}MnO_3$) on $SrTiO_3$ substrates with orientations (100), (110) and (111) by metalorganic aerosol deposition (MAD) technique and studied the dependence of the planar Hall effect on the temperature and applied magnetic field as well as film thicknesses (5 nm to 30 nm) and Hall bar structure dimensions (Hall bar width from 10 μm to 300 μm). Financial support from EU FP 7 Project IFOX is acknowledged. [1] J. Appl. Phys. 93, 6354 (2003)

MA 55.97 Fri 10:30 P2

Gilbert damping in Co_2-based Heusler compounds — •Daniel Ebke[1], Olga Meshcheriakova[1], Albrecht Köhler[1], Lukas Wollmann[1], Steffen Hausdorf[1], Andreas Kehlberger[2], Günter Reiss[3], Gerhard Fecher[1], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Johannes Gutenberg University, Institute of Physics, Mainz, Germany — [3]Thin Films and Physics of Nanostructures, Bielefeld University, Germany

To reach a low critical current threshold for spin torque switching devices, materials with a low Gilbert damping constant were in the focus of many research groups in the past years. On the other side, a high Gilbert damping is indispensable to realize short switching times in devices such as read heads for hard disk drives. To realize high TMR or GMR ratios, materials with a high spin polarization P are needed. Layer structures that contain Heusler compounds are excellent candidates due to their extraordinary good tunability of their physical properties to meet all criteria upon request.

In this work we have investigated the influence of atomic ordering and crystal structure to the Gilbert damping constant of Co_2-based Heusler compound thin films. The damping constant was determined by FMR measurements as function of post annealing temperature and film thickness.

MA 55.98 Fri 10:30 P2

$A_2[FeX_5(H_2O)]$ a new family of multiferroic and linear magnetoelectric materials — •Matthias Ackermann[1], Sebastian Salm[2], Thomas Lorenz[2], Petra Becker[1], and Ladislav Bohatý[1] — [1]Institut für Kristallographie, Universität zu Köln, Germany — [2]II. Physikalisches Institut, Universität zu Köln, Germany

Magnetoelectric coupling phenomena, such as the linear magnetoelectric effect, have attracted considerable interest during the last decade, especially after the discovery of spin-driven multiferroicity in magnetically frustrated systems. Recently, we indentified $(NH_4)_2[FeCl_5(H_2O)]$ as new multiferroic material with a strong magnetoelectric coupling and with rather complex magnetic field versus temperature phase diagrams [1]. It belongs to the family of erythrosiderite-type compounds $A_2[FeX_5(H_2O)]$, where A stands for an alkali metal or ammonium ion and X for a halide ion. The magnetic properties of the family have been subject of various investigations in the past. Almost all members studied so far have been identified as collinear antiferromagnets [2]. In this contribution now we present a detailed investigation of the linear magnetoelectric properties and their anisotropy of the alkali compounds $K_2[FeCl_5(H_2O)]$, $Rb_2[FeCl_5(H_2O)]$ and $Cs_2[FeCl_5(H_2O)]$. Detailed magnetic field versus temperature phase diagrams are presented.

This work was supported through the Institutional Strategy of the University of Cologne within the German Excellence Initiative.

[1] Ackermann M et al. 2013 *New J. Phys.* (in press, arXiv:1308.0285)

[2] Carlin R L et al. 1985 *Coord. Chem. Rev.* **65** 141

MA 55.99 Fri 10:30 P2

Microscopic and macroscopic studies on the magnetoelectric coupling in chiral multiferroics — •Tobias Cronert[1], Jonas Stein[1], Jeannis Leist[3], Joachim Hemberger[1], Petra Becker-Bohatý[2], Ladislav Bohatý[2], Agung Nugroho[4], Karin Schmalzl[5], Götz Eckold[3], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Kristallographie, Universität zu Köln — [3]Institut für Physikalische Chemie, Universität Göttingen — [4]Institut Teknologi Bandung — [5]JCNS at Institut Laue-Langevin Grenoble

In the chiral magnets $MnWO_4$ and $RMnO_3$ ferroelectric polarisation is directly induced by the non-collinear magnetic structure. We present microscopic neutron scattering studies and macroscopic measurements of the ferroelectric polarisation and of the magnetic structure in these materials. Using a stroboscopic method the control of the chiral magnetism by an external electric field is determined by polarised neutrons while the switching of ferroelectric order can be directly followed in the time-domain with a sawyertower-like circuit. $MnWO_4$ exhibits rather long rise times of 10ms and strong asymmetries that depend on the cooling history. Relaxation times and hysteresis curves of $DyMnO_3$ in dependence of electric field, temperature and thickness were also recorded indicating a non regular behavior.

MA 55.100 Fri 10:30 P2

DFT investigations of $BiFeO_3$ phases: bandgap and dielectric function — •Sebastian Schwalbe, Torsten Weissbach, Cameliu Himcinschi, and Jens Kortus — TU Bergakademie Freiberg, Institute of Theoretical Physics, D-09596 Freiberg, Germany

$BiFeO_3$ (BFO) is the most extensively studied multiferroic material. Recently it has been shown that BFO can adapt to different crystal structures in strained thin films. Raman and optical measurements on strained BFO films on different substrates ($LaAlO_3$, $TbScO_3$) found a change in band gap and dielectric function. Here we present a density functional study using different approaches (LDA + U, hybrid functionals, mBJ [1]) to determine the bandgap for a variety of strained crystal structures of BFO. A proper description of the band gap and the calculation of the dielectric function is the focus of our work. The results are compared to experimental optical spectroscopy data.

[1] F. Tran and P. Blaha, Phys. Rev. Lett. 102, 226401 (2009).

MA 55.101 Fri 10:30 P2

Quantum heat engine operating with multiferroic chain working substance — •Maryam Azimi[1], Levan Chotorlishvili[1], Sunil Kumar Mishra[2], Teimuraz Vekua[3], Wolfgang Hübner[4], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]Department of Physics, Indian Institute of Technology, Banaras Hindu University, Varanasi - 221005, India — [3]Institut für Theoretische Physik, Leibniz Universität Hannover, 30167 Hannover, Germany — [4]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, PO Box 3049, 67653 Kaiserslautern, Germany

In this work we study the quantum Otto engine[1,2] with the working substance of frustrated ferromagnetic spin-1/2 chain[3,4]. The presence of the finite spin chirality in the working substance allows driving a cycle by the external electric field. We observe a direct connection between chirality, entanglement and the efficiency of the engine and find the existence of a threshold temperature above which the pair correlations in the system quantified by thermal entanglement decay to zero. We also find a direct correlation between threshold temperature of pair entanglement, with the spin chirality and the minimum of the fidelities related to the electric and magnetic field. The efficiency of the quantum Otto cycle shows a saturation plateau with the increase of the electric field amplitude. [1]H. T. Quan et al., Phys. Rev.E. 76, 031105 (2007). [2]R. Wang et al., Phys. Rev. E. 86,021133 (2012). [3]M. Mostovoy, Phys. Rev. Lett. 96, 067601 (2006). [4]M. Menzel et al., Phys. Rev. Lett. 108, 197204 (2012).

MA 55.102 Fri 10:30 P2

Strain and interface effects on magnetic order of La0.7Ca0.3MnO3/SrTiO3 superlattices — •Sujit Das[1,2], Andreas Herklotz[1,2], Er Jia Guo[2,1], and Kathrin Doerr[2,1] — [1]IFW Dresden, Postfach 270116, 01171 Dresden, Germany — [2]Institute for Physics, MLU Halle-Wittenberg, 06099 Halle, Germany

We explore the strain-induced changes of magnetic order in epi- taxially grown [La0.7 Ca0.3 MnO3 (2.6nm)/SrTiO3 (6.3nm)]15 superlattices (SLs). SLs are simultaneously grown by Pulsed Laser Deposition (PLD) on (100)-oriented SrTiO3 (STO), LaAlO3 (LAO) and piezoelectric 0.72Pb (Mg1/3Nb2/3)3-0.28PbTiO3 (PMN-PT) substrates in order to obtain different residual strain states. Structural characterization by X-ray diffraction (XRD) shows coherent growth on STO and non-coherent growth with two different residual strain states of the SLs on LAO and PMN-PT. The La0.7 Ca0.3 MnO3 layers are under increasing tensile strain (ϵ) from the SL on LAO (ϵ=1.0%) via that on STO (ϵ=1.7%) to that on PMNPT (ϵ=1.8%). Both, Tc and the magnetization decrease with increasing tensile strain. Application of reversible biaxial compression using the PMN-PT substrate reveals the direct strain effect on magnetic order. Comparing the latter with the magnetic data obtained for the three substrates reveals the importance of both, the elastic strain and a second parameter related to the interface structure.

MA 55.103 Fri 10:30 P2

The High-Field Multiferroicity of $GdMnO_3$ and $DyMnO_3$ explored by Resonant Soft X-Ray Scattering — •Enrico Schierle[1], Victor Soltwisch[1], Sven Landsgesell[1], Fabiano Yokaichiya[1,2], Detlef Schmitz[1], Andrej Maljuk[1,3], Ralf Feyerherm[1], Dimitri Argyriou[1,4], and Eugen Weschke[1] — [1]Helmholtz-Zentrum Berlin — [2]Laboratrio Nacional de Luz Sincrotron, Brasil — [3]IFW, Dresden — [4]ESS, Lund, Sweden

Some of the orthorhombic REMnO3 oxides are prototype single-phase multiferroic compounds characterized by a strong coupling of ferroelectric (FE) and magnetic order. This allows for magnetic control of FE polarization P [1] and magnetic response to applied electric fields [3]. The zero-field multiferroic phases, characterized by P along c, are well understood. Here, magnetic Mn cycloids induce P [3] but also RE order has been shown to have significant contributions[3-5]. Only little is known about the magnetic high field phases of these materials with FE P switched to show along a. We employed Resonant Soft X-Ray Scattering to explore the electronic ordering of the RE-4f and Mn-3d and its relation to ferroelectricity. We will compare the behavior observed for the P_a phases of $DyMnO_3$ and $GdMnO_3$ which show surprising differences. The study has been performed 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 55.104 Fri 10:30 P2

Investigation of Binding Energies in Multiferroic Layer Systems — •Martin Welke[1], Paula Huth[1], Kathrin Dabelow[2], 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, Martin-Luther-Universität Halle-Wittenberg

The work presented deals with the electronic structure of ferroelectric $BaTiO_3$ (BTO) and additional ferrimagnetic layers on top. BTO has several phase transitions while the biggest change occurs during the phase transition from tetragonal to cubic where the electrical polarization disappears. In conventional XPS measurements, there are spontaneous shifts in core-level binding energies while heating or cooling through that last mentioned phase transition. That observation was proposed to be a surface effect.[1] In order to check this property, different photon energies ranging from 2000 to 6000 eV have been used to excite photoelectrons with higher kinetic energy to probe the sample in greater depths. Core levels of all contained elements were studied showing shifts in binding energy as well. Therefore, we assume it is not a plain surface effect but might occur throughout the whole bulk of the ferroelectric material. Additionally, layers of $CoFe_2O_4$ and $NiFe_2O_4$ on BTO prepared by PLD have been investigated showing these shifts in binding energies as well. Theoretical simulations were performed in order to obtain a detailed understanding of the influence of the crystal lattice of $BaTiO_3$ and of the shifts observed in binding energies.

[1] L. Makhova et al., Phys. Rev. B, 2011, 83, 115407

MA 55.105 Fri 10:30 P2

Spin density wave ordering in $Ca_{0.5}Sr_2$1.5RuO_4 studied by neutron scattering — •Stefan Kunkemöller[1], Agung Nugroho[2], Yvan Sidis[3], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, D-50937, Germany — [2]Faculty of Mathematics and Natural Sciences, Jl. Ganesa 10 Bandung, 40132, Indonesia — [3]Laboratoire Léon Brillouin, C.E.A./C.N.R.S., F-91191 Gif sur Yvette CEDEX, France

The families of layered ruthenates have attracted strong interest mostly due to the appearance of unconventional superconductivity in pure Sr_2RuO_4. The question wether the magnetic fluctuations are relevant for the superconducting pairing in Sr2RuO4 and if so which ones remains an interesting open issue. The spin density wave ordering in $Ca_{0.5}Sr_{1.5}RuO_4$ is studied by polarized and unpolarized neutron diffraction experiments. It exhibits quasistatic correlations below 20 K at the incommensurate wave vector at which Sr_2RuO_4 shows strong inelastic fluctuations driven by Fermisurface nesting. The magnetic character of the signal and the orientation of the ordered moments along the c direction can be ascertained by neutron polarization analysis. The magnetic ordering at low temperatures is very similar to that found upon minor Ti doping of Sr_2RuO_4 underlining, that this incommensurate SDW is the dominant magnetic instability of the unconventional superconductor Sr_2RuO_4.

MA 55.106 Fri 10:30 P2

Influence of shuttered growth vs. co-deposition on magnetic depth profile of [La2/3Sr1/3]n±1[Mn]n[O]3n±1/SrTiO3 — •Alexandra Steffen[1], Sabine Pütter[1], Jürgen Schubert[3], Willi Zander[3], Stefan Mattauch[1], and Thomas Brückel[1,2] — [1]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH, Outstation at MLZ, Lichtenbergstr. 1, 85748 Garching — [2]Jülich Centre for Neutron Science JCNS and 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

In transition metal oxide thin films the precise control of stoichiometry can explain phenomena like ferromagnetism or superconductivity at interfaces, e.g. LaAlO3/SrTiO3 [1]. Here, we grew [La2/3Sr1/3]n±1[Mn]n[O]3n±1 layers on SrTiO3 by Oxide Molecular Beam Epitaxy. In our study we compared the influence of deposition methods, co-deposition and shuttered growth on the magnetic depth profile of different [La2/3Sr1/3] to Mn ratios. During growth, RHEED oscillations [2] were constantly monitored to observe the structural quality. The samples were characterized structurally (LEED, XRR, XRD) and magnetically (SQUID). The stoichiometry was further checked via RBS. The relation of different deposition methods and depth-dependent distribution of magnetic moments was achieved via Polarized Neutron Reflectometry at TREFF@MLZ.

[1] M. Warusawithana et al., Nat. Commun. 4, 2351 (2013)
[2] J. Neave and B. Joyce, Appl. Phys. A 31, 1 (1983)

MA 55.107 Fri 10:30 P2

Hybridization between surface and bulk electronic structure of the topological insulator Sb_2Te_3(0001) — •Henriette Maass[1,2], Christoph Seibel[1,2], Hendrik Bentmann[1,2], Kazuyuki Sakamoto[3], Kenya Shimada[4], and Friedrich Reinert[1,2] — [1]Experimentelle Physik VII, Universität Würzburg, D-97074 Würzburg — [2]Gemeinschaftslabor für Nanoanalytik, Karlsruher Institut für Technologie KIT, D-76021 Karlsruhe — [3]Graduate School of Advanced Integration Science, Chiba University, Chiba 263-8522, Japan — [4]Hiroshima Synchrotron Radiation Center, Hiroshima University, Higashi-Hiroshima 739-0046, Japan

We investigated the surface band structure of the topological insulator Sb_2Te_3(0001) with respect to bulk and surface contributions using photon energy dependent angle-resolved photoelectron spectroscopy (ARPES) and spin-resolved ARPES. Our results render direct evidence for a spin-orbit split trivial surface state which shows a Rashba-type character for small $k_\parallel$ but develops an unusual connecting behavior with bulk states for larger $k_\parallel$ in accordance with theoretical predictions. Our findings on the topological surface state (TSS) indicate a coexistence with bulk states in the valence band regime without considerable hybridization, unlike previous results on the isostructural materials Bi_2Se_3(0001) and Bi_2Te_3(0001). On the other hand we find a photon energy dependance of the TSS at higher binding energies which points to a $k_\perp$-dispersion and an increasing bulk character.

[1] Seibel *et al.* PRB 86, 161105(R) (2012)

MA 55.108 Fri 10:30 P2

Thin film preparation of the topological insulator Bi_2Te_3 by co-sputtering — •Mike Gotzmann[1], Christian Sterwerf[1], Jan-Michael Schmalhorst[1], Günter Reiss[1], and Gregor Mussler[2] — [1]Thin Films and Physics of Nanostructures, Bielefeld University, Germany — [2]Peter Grünberg Institute Semiconductor Nanoelectronics (PGI-9), Jülich, Germany

Topological insulators are a new class of promising materials for spintronic devices. Due to their bulk band gap, they show an ordinary insulating behavior in the bulk, whereas on the surface the conducting properties and in particular the spin direction, are conserved.[1]

Thin epitaxial Bi_2Te_3 films were prepared by dc and rf magnetron co-sputtering and molecular beam epitaxy from elemental targets onto various substrates such as BaF_2, Si and Al_2O_3. To achieve a high bulk resistivity, the films were doped with Sn. The crystallographic properties of the Bi_2Te_3 films were investigated by x-ray diffraction and reveal a high degree of structural order. Resistance measurements were performed down to 15K to determine the electronic behavior of the films.

[1] M. Hasan and C. Kane (2010). Reviews of Modern Physics, 82(4), 3045–3067.

MA 55.109 Fri 10:30 P2

Pyrochlore Iridates: Possible Candidates for the Realization of Weyl Nodes — •Andreas Wörfel[1], Matthias Opel[1], Stephan Geprägs[1], and Rudolf Gross[1,2] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, Technische Universität München, 85748 Garching, Germany

Pyrochlore iridates $A_2Ir_2O_7$ (A =Y or a rare-earth ion) offer a promising system for studying the interplay of strong spin-orbit coupling, electronic correlations, and band topology effects. Novel phases such as axial or topological insulators, and Weyl semimetals have been predicted in these compounds [1]. In particular, $Nd_2Ir_2O_7$ is proposed to exhibit Weyl semimetal nodes, where two non-degenerate bands touch each other creating a local linear dispersion. These nodes are topologically protected making Weyl states absolutely robust to perturbations.

Here, we report on a detailed study of the structural, magnetic, and magnetotransport properties of bulk samples as well as thin films of $Nd_2Ir_2O_7$. Epitaxial $Nd_2Ir_2O_7$ thin films were deposited on single-crystalline Y:ZrO_2 (111) substrates using laser-MBE, whereas polycrystalline bulk $Nd_2Ir_2O_7$ samples were fabricated by a standard solid state reaction. These samples show a metal to insulator transition (MIT) at around $T_{\rm MIT} \simeq 33$ K. The MIT is accompanied by a bifurcation of the magnetic susceptibility in field-cooled (FC) and zero-field-cooled (ZFC) conditions, suggesting the existence of a magnetic long-range ordered state for temperatures $T < T_{\rm MIT}$.

[1] X. Wan *et al.*, Phys. Rev. B **83**, 205101 (2011).

MA 55.110 Fri 10:30 P2

THz spectroscopy on the topological insulator Bi2Te3 — •Nick Borgwardt[1], Gregor Mussler[2], Malte Langenbach[1], Joachim Hemberger[1], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln, Cologne, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, Germany

Topological insulators are one of the most discussed areas of current research in condensed matter physics. Bi_2Te_3 is a 3D topological insulator with the advantage of a relatively large band gap (∼0.2 eV) and a reduced bulk conductivity. Thin films of Bi_2Te_3 with thicknesses between 9nm and 30nm were grown on high-resistance Si (111) wafers using MBE. By means of cw-THz spectroscopy based on photomixing in combination with far-infrared Fourier spectroscopy, we studied the transmission in the frequency range from 3 cm^{-1} to 700 cm^{-1} as a function of temperature. The goal is to distinguish between surface conductance and bulk conductivity.

MA 55.111 Fri 10:30 P2

Thin films of the topological Half-Heusler compound YPtBi — Alexander Kronenberg, Hans Joachim Elmers, Mathias Kläui, and •Martin Jourdan — Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz

Half-Heusler materials of the family LaPtBi are predicted to show 3D-topological order [1] i.e. to present topologically protected electronic surface states. Additionally, according to band structure calculations, a bulk band gap can be opened around the Fermi level by lateral strain [2]. The planned in situ spin-resolved ARUPS on epitaxial thin films is the ideal tool to investigate the electronic structure including surface states of thin films of this. We present first results on the preparation of thin films of the YPtBi compound. Crystalline quality as checked by x-ray diffraction and morphology investigated by atomic force microscopy are compared for films deposited by RF-magnetron sputtering from a stoichiometric compound target as well as from three separate elementary sputtering sources. [1] Chadov et al. Nature Materials 9, 541 (2010) [2] Zhang et al. Appl. Phys. Lett. 99 071901 (2011)

MA 55.112 Fri 10:30 P2

***Ab-initio* calculations and ARPES measurements for the bulk topological insulators Bi_2Se_3 and Bi_2Te_3** — •I. Aguilera[1], I.A. Nechaev[2], M. Michiardi[3], R.C. Hatch[3], M. Bianchi[3], D. Guan[3], C. Friedrich[1], J.L. Mi[3], B.B. Iversen[3], V.E. de Carvalho[4], L.O. Ladeira[4], N.G. Teixeira[4], E.A. Soares[4], Ph. Hofmann[3], E.V. Chulkov[5], and S. Blügel[1] — [1]Forschungszentrum Jülich — [2]Tomsk State University — [3]Aarhus University — [4]Universidade Federal de Minas Gerais — [5]Universidad del Pais Vasco

Most theoretical studies of topological insulators were so far based on model Hamiltonians, parameter-dependent tight-binding descriptions, and density functional theory employing either the local-density (LDA) or generalized gradient approximation. But recently, many-body calculations within the GW approximation were attracting much attention in the study of these materials. In this work, we have performed LDA and GW calculations for bulk Bi_2Se_3 and Bi_2Te_3 within the all-electron FLAPW formalism. We present a detailed comparison of the calculations to angle-resolved photoemission spectroscopy (ARPES) data obtained over a wide range of photon energies. We find that the GW corrected bands agree much better with experiment than the LDA bands. In particular, the characteristic "camelback" shape of the valence band around the Γ point flattens in GW in the case of Bi_2Te_3 and disappears for Bi_2Se_3, in accordance with experiments.

Work is supported by the Helmholtz Virtual Institute for Topological Insulators (VITI) and the Alexander von Humboldt Foundation.

MA 55.113 Fri 10:30 P2

Spin dynamics and magnetic interactions of Mn dopants in the topological insulator Bi_2Te_3 — •S. Zimmermann[1,2], V. Kataev[1], Huiwen Ji[3], R.J. Cava[3], and B. Büchner[1,2] — [1]IFW Dresden, Germany — [2]TU Dresden, Germany — [3]Department of Chemistry, Princeton University, 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. 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 [2]. 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. In addition the results from magnetization and transport measurements are taken into account to discuss the Mn spin relaxation via conducting states and the establishment of ferromagnetic order. [1] R. Yu et al., Science **369**, 61 (2010); [2] S. E. Barnes, Adv. Phys. **30**, 801 (1981); [3] Y.S. Hor et al., PRB **81**, 195203 (2010)

MA 56: Graphene: Interaction with the substrate (with DY/DS/O/TT)

Time: Friday 11:15–13:00 Location: POT 081

MA 56.1 Fri 11:15 POT 081

Phonons of graphene on metallic and semiconductor surfaces, an ab-inito approach — •Alejandro Molina-Sanchez and Ludger Wirtz — Physics and Materials Science Research Unit, University of Luxembourg, Luxembourg

The interaction of graphene with substrates can alter its electronic and vibrational properties and is relevant for the practical use of graphene. In this work, we describe the graphene-substrate interaction through the theoretical study of the vibrational properties. We focus on three paradigmatic cases where the interaction strength changes gradually: graphene@BN, graphene@Ir(111), and graphene@SiC (i.e., the buffer layer). We use ab-initio methods to obtain the phonon modes, the density of states, and the strength of the electron-phonon coupling. When we deal with large supercells, we use an unfolding scheme to visualize the phonon bands in the primitive unit cell. Thus, we can distinguish clearly the changes in the phonon dispersion of perturbed-graphene with respect to the one of pristine graphene. Graphene on boron nitride exhibits a weak interaction but a non-negligible shift of the 2D Raman band. We explain this observation as due to a weakening of the electron-phonon interaction via screening of electron-electron correlation by the dielectric substrate. Graphene on iridium, also displays weak interaction but the underlying material is a metal. This leads to an even more pronounced screening of the electron-electron interaction in graphene. In the last case, we study the buffer layer of graphene on silicon carbide. The hybridization of graphene with silicon carbide changes the electronic structure of graphene and the phonon bands.

MA 56.2 Fri 11:30 POT 081

The (3×3)-SiC($\bar{1}\bar{1}\bar{1}$) reconstruction: Surface phase equilibria near the graphene formation regime on 3C-SiC($\bar{1}\bar{1}\bar{1}$) — •Lydia Nemec[1], Florian Lazarevic[2], Patrick Rinke[1], Volker Blum[3], and Matthias Scheffler[1] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]AQcomputare GmbH, Chemnitz — [3]MEMS Department, Duke University, Durham, NC, USA

To refine the growth quality of epitaxial graphene on the C-side of SiC and improve the resulting electronic character of these films, it is important to understand the atomic- and electronic-structure of the interface. A phase mixture of different surface phases is observed just when surface graphitization first sets in. However, the atomic structure of some of the competing surface phases, as well as of the SiC-graphene interface, is unknown.

We performed a density functional theory study on the C-side of the polar SiC($\bar{1}\bar{1}\bar{1}$) surface using the all-electron, numeric, atom-centered basis function code FHI-aims. The formation energy of different reconstructions and model systems for the interface is presented within the thermodynamically allowed range.

The surface energies of the known (2×2) phase is compared with several structural models of the (3×3) phase proposed in the literature. In comparison all the previously suggested (3×3) models are higher in energy than the known (2×2) phase. We present a new model for the (3×3) reconstruction. Its formation energy crosses that of the (2×2) phase just at the carbon rich limit of the chemical potential, which could explain the observed phase mixture.

MA 56.3 Fri 11:45 POT 081

Reststrahl band assisted photocurrents in epitaxial graphene layers — •P. Olbrich[1], C. Drexler[1], L.E. Golub[2], S.N. Danilov[1], V.A. Shalygin[3], V.A. Shalygin[3], R. Yakimova[4], S. Lara-Avila[5], S. Kubatkin[5], B. Redlich[6], R. Huber[1], and S.D. Ganichev[1] — [1]University of Regensburg, Regensburg, Germany — [2]Ioffe Institute, St. Petersburg, Russia — [3]State Polytechnic University, St. Petersburg, Russia — [4]Linköping University, Linköping, Sweden — [5]Chalmers University of Technology, Göteborg, Sweden — [6]FOM Institute for Plasma Physics, Nieuwegein, The Netherlands

We report on the observation of reststrahl band assisted photocurrents in epitaxial graphene on SiC. The samples were excited by the infrared radiation from the tunable free electron laser "FELIX" and a CO_2 gas laser [1]. We show that the photoresponse due to linearly (circularly) polarized mid-infrared light is strongly enhanced (suppressed) in the vicinity of the reststrahl band of SiC. Our data, in particular a complex spectral behavior, are well described by the developed theory taking into account photon drag and photogalvanic effects affected by an enhanced light-matter interaction in the range of substrate's negative dielectric function in its reststrahl band. Moreover, our work demonstrates that substrate phonons strongly influence the transport properties of the carriers in graphene.

[1] P. Olbrich *et al.*, arXiv:1308.0123

MA 56.4 Fri 12:00 POT 081

Towards superlattices: Lateral bipolar multibarriers in graphene — •Martin Drienovsky[1], Franz-Xaver Schrettenbrunner[1], Andreas Sandner[1], Ming-Hao Liu[2], Fedor Tkatschenko[2], Klaus Richter[2], Dieter Weiss[1], and Jonathan Eroms[1] — [1]Institut für Experimentelle und Angewandte Physik Universität Regensburg — [2]Institut für Theoretische Physik Universität Regensburg

We report on transport properties of monolayer-graphene (MLG) with a laterally modulated charge carrier density profile. For that we employed a planar back gate and striped top gate electrodes of 25 nm width and a spacing of 100 nm up to 200 nm, separated from the MLG by an Al_2O_3 dielectric. Tuning of top and back gate voltages gives rise to multiple potential barriers and wells, enabling the investigation of resistance either in the unipolar or the bipolar transport regime. In the latter pronounced single- and multibarrier Fabry-Pérot (FP) resonances are observed. The experimental data of different devices with alternating numbers of top gate stripes and pitch, taken at different temperatures, is consistent with a ballistic transport calculation, employing a realistic potential profile, extracted from classical electrostatic simulation combined with the quantum capacitance model. The origin of resistance oscillations in our multibarrier graphene system can be explained in the FP-picture, without resorting to an artificial band structure.

MA 56.5 Fri 12:15 POT 081

Scanning Tunnelling Spectroscopy of Moiré Patterns on Graphene/Rh(111) — •Anne Holtsch, Tobias Euwens, Hussein Schanak, and Uwe Hartmann — Institut für Experimentalphysik, Universität des Saarlandes, Saarbrücken

The lattices of graphene and Rh(111) provide a difference of approximately 9% between the two lattice constants. This mismatch results in the formation of a Moiré pattern with a lattice constant of 2.9 nm. Each unit cell of the pattern exhibits four regions where the graphene lattice is aligned differently with respect to the Rh(111) atoms. Scanning tunnelling microscopy and spectroscopy are used to investigate changes in the electronic properties at the four regions of the Moiré unit cell. Density functional theory (DFT) calculations show that a decreasing C-Rh distance at different symmetry points coincides with an increasing interaction strength between graphene and Rh(111) [1]. The locations of the minima in the dI/dV curves are identical for the different symmetry regions. Beyond the minimum, the symmetry points show differences in the dI/dV curves according to the C-Rh interaction strength.

[1] M. Iannuzzi and J. Hutter, Surf. Sci. 605, 1360 (2011).

MA 56.6 Fri 12:30 POT 081

Varied Moiré patterns of graphene/Rh(111) measured by scanning tunnelling microscopy — •Tobias Euwens, Anne Holtsch, Hussein Schanak, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P.O. Box 151150, D-66041 Saarbrücken

Scanning tunnelling microscopy measurements on graphene deposited on a Rh(111) surface are conducted to investigate the superstructures that originate from the different lattice parameters of the graphene and the substrate. Different kinds of superstructures, also called Moiré patterns, can be seen in the resulting images. Their origin lies in either the surface inhomogenities of the Rh(111) substrate or in the form of folds and steps in the graphene itself. Knowing the properties of the growth of graphene on the rhodium surface is important for the construction of more complex graphene-based electronics. Understanding the specific structure of the Moiré patterns can help in that regard as it relays information about the angle between the carbon and the rhodium lattice and potential reasons for the twisting between the two lattices.

MA 56.7 Fri 12:45 POT 081

Impact of the substrate on the electronic properties of graphene — •Hussein Shanak, Anne Holtsch, Tobias Euwens, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P.O. Box 151150, D-66041 Saarbrücken

Electronic properties of graphene grown on different substrates such as Rh, Cu and SiO2 were investigated using scanning tunnelling microscopy and spectroscopy. The different kinds of substrates result in different types of superstructures due to the mismatch between graphene and substrate. Comparison of the electronic properties obtained for graphene on the different substrates leads to a better understanding of the graphene doping behaviour. Additionally, the existence of different superstructures leads to different growing properties of the materials on top of graphene itself.