MA 45: Magnetic Coupling and Spin Structures

Time: Thursday 15:00–18:45 Location: H10

MA 45.1 Thu 15:00 H10

Direct spectroscopic observations of non-rotatable magnetic moments in Fe50Mn50/Co bilayer using XMCD — •Patrick Audehm, Mathias Schmidt, Gisela Schütz, and Eberhard Goering — MPI for Intelligent Systems, formerly MPI for Metals Research, Stuttgart, Germany

The XMCD (X-ray Magnetic Circular Dichroism) is a unique tool for small microscopic magnetic moments, which allows to identify even the smallest fraction of magnetic moments in an element specific way and their separation in spin and orbital contributions. By a double rotation of polarization and magnetization, the dichroic signal is sensitive to non-rotatable magnetic moments. We have performed highly sensitive XMCD studies on a Exchange Bias (EB) system with Fe50Mn50 and Co layer on top. Our transition metal L2,3 edge XMCD analysis of the top (FM) and the underlying FeMn layer (AF) for rotatable magnetic moments provides the pure-metal like spin dominated XMCD spectra. In contrast to this, the non-rotatable moment*s spectra exhibit a nearly pure orbital character. In order to prove this spectacular result, we have verifyed the temperature dependency of this effect, with reduced EB at higher temperature. These experiments point towards the existence of locally loaded spin-orbit-coupling springs on the atomic level. This result is of great importance and has to be considered beyond EB systems as a local source for anisotropy energy in transition metal compounds.

MA 45.2 Thu 15:15 H10

Studies on thermal activation of CoFe/MnIr exchange bias layer systems — Timo Ueltzhöffer, •Henning Huckfeldt, Alexander Gaul, and Arno Ehresmann — Center for Interdisciplinary Nanostructure Science and Technology (CINSaT) and Department of Physics, University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Exchange bias layer systems consisting of 10 nm $Mn_{83}Ir_{17}$ and 6.5 nm $Co_{70}Fe_{30}$ deposited by RF-sputter deposition were analyzed systematically concerning the temperature dependence on the activation of the antiferromagnet and the exchange bias coupling parameters. The results will be presented in comparison to those published by O'Grady *et al.*[1]

A general insight into the blocking temperature distribution was achieved. In addition, competitive effects like interface diffusion could be clearly identified, starting well below the Néel-temperature. Using these measurements a controlled setting of the antiferromagnet can be achieved leading to reproducible sample parameters and measurements.

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

MA 45.3 Thu 15:30 H10

Effect of CoO/Ni exchange coupling on perpendicular magnetization of Ni films on Pd(001) — •Piotr Kuświk[1], Pedro L. Gastelois[1,2], Waldemar A. A. Macedo[2], Marek Przybylski[1,3], and Jürgen Kirschner[1,4] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]Centro de Desenvolvimento da Tecnologia Nuclear, Belo Horizonte, Brazil — [3]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland — [4]Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

The exchange bias effect has been widely investigated in systems presenting in-plane anisotropy. Even more important candidates for developing new technologies are the systems combining magnetic out-of-plane anisotropy and perpendicular exchange bias. We have shown that CoO/Ni bilayer epitaxially grown on Pd(001) exhibits not only the perpendicular magnetization, but also the perpendicular exchange bias effect. Moreover, after cooling it down to T=5K, the initially in-plane easy magnetization axis of the Ni underlayers in the thickness range of 17-25ML, exhibits not only strong exchange coupling, but also perpendicular anisotropy. The coupling at the CoO/Ni interface is indicated by strongly enhanced coercivity with respect to the uncovered Ni films, and exchange bias field of 200Oe. At T=290K, coercivity decreases to the value for the uncovered Ni films and exchange bias disappears, which indicates that coupling exists only below the Néel temperature of CoO.

MA 45.4 Thu 15:45 H10

Exchange Bias effect in coupled systems of ferrimagnetic $Fe_{100-x-y}Co_xTb_y$ and ferromagnetic $[Co(0.4nm)/Pt(0.8nm)]_{10}$-multilayers — •Birgit Hebler[1], Christian Schubert[1], Florin Radu[2], and Manfred Albrecht[1] — [1]Institute of Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]Hemholtz-Zentrum Berlin für Materialen und Energie, D-12489 Berlin, Germany

A large exchange bias effect is an important aspect in the miniaturizing of prospective spintronic devices. In this regard out-of-plane anisotropy heterostructures consisting of amorphous ferrimagnetic (FI) rare-earth/transition metal alloys and ferromagnetic (FM)[Co/Pt]-multilayer stacks attracted much attention due to the occurance of a large exchange bias field of about 10 kOe [1]. In our study we prepared FI/FM bilayers of $Fe_{100-x-y}Co_xTb_y$ (20nm) and a $Co(0.4nm)/Pt(0.8nm)]_{10}$-multilayer stack by magnetron-sputtering in a UHV-chamber at room temperature. We measured the magnetization reversal processes at different temperatures by using a SQUID-VSM to analyse how the variation of the composition of the ternary alloy influences the magnetic exchange interactions at the interface and consequently the exchange bias field.

[1] S. Romer et al., Appl. Phys. Lett. 101, 222404 (2012)

MA 45.5 Thu 16:00 H10

Crystallite size determination of exchange biased thin film systems with the Guinier camera *Huber G 653* — •Markus Meyl and Arno Ehresmann — Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

Exchange biased thin film systems are structurally characterised with the X-ray Guinier thin film camera *Huber G 653*. One advantage of this Guinier camera includes the use of a focussing monochromator between the X-ray tube and the thin film system for achieving strictly monochromatic X-rays. Another benefit lies in the very small angle of incidence ($< 10°$) between the incident X-rays and the surface of the sample to achieve a large effective distance in the thin films and thereby higher diffraction intensities. The measurement geometry behind the monochromator is called Seemann-Bohlin geometry. In this geometry the focal line of the monochromator, the surface of the sample and the detector entrance slit are located on a constant focussing cylinder. During one measurement the angle of incidence is constant and the detector entrance slit moves on the focussing cylinder. Reflected X-rays are measured when Bragg's law is fulfilled. As a consequence the Guinier thin film goniometer is especially suitable for analysing thin polycrystalline films on a crystalline or amorphous substrate. From the diffraction spectrum e.g. crystallite sizes can be calculated using Fourier analysis. Exemplary results of exchange biased thin film systems deposited by RF-sputtering will be presented.

MA 45.6 Thu 16:15 H10

Direct manipulation of the uncompensated antiferromagnetic spins — •Amitesh Paul[1], Neelima Paul[2], Stefan Mattauch[3], and Peter Böni[1] — [1]Technische Universität München, Physik Department E21, — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, — [3]Jülich Centre for Neutron Science JCNS, Forschungszentrum Jülich GmbH,

Incident ion energy to matrix electrons of a material is dissipated within a narrow cylinder surrounding the swift heavy ion path. The temperature of the lattice exceeds the melting point and upon quenching causes nanometric modifications. We present here a unique ex situ approach in manipulating the uncompensated spins in antiferromagnetic layers of ferro-/antiferromagnetic (CoO-Co) exchange coupled systems on a nanometric scale. We use the impact of relativistic heavy ion (1-2 GeV) irradiation on such systems. We find an increase in the bias field and a restoration of the reversal via domain nucleation in the trained state. These are identified as plausible results of ion-induced antiferromagnetic ordering with little or no effect on the layer structure. This study demonstrates, therefore, the possibility of nanoscale tailoring of exchange coupled systems that survive even in the trained state.

15 min. break

MA 45.7 Thu 16:45 H10

^{57}Fe NMR as a local probe for chiral ferromagnetism in non-centrosymmetric FeGe — •Michael Baenitz[1], Panchanan Khuntia[1], Markus Schmidt[1], Ulrich Roessler[2], and Heribert Wilhelm[3] — [1]Max-Planck-Institute for the Chemical Physics ofSolids, 01187 Dresden, Germany — [2]Leibniz Institutefor Solid State and Materials Research - IFW, 01171 Dresden, Germany — [3]Diamond Light Source Ltd, Didcot, OxfordshireOX11 0DE, United Kingdom

The helical ferromagnet FeGe belongs to the class of B20 compounds with non-centrosymmetric structure being essential for new forms of ferromagnetic phases (confined or modulated Skyrmion phase). From an NMR point FeGe is a prototype system to study chiral excitations directly "on-site" via the ^{57}Fe nucleus which (in contrast to ^{55}Mn with nuclear spin S=5/2) has a spin of S=1/2 with the big advantage of an absent quadrupolar interaction which usually creates broad NMR lines and prevents detailed investigations of the anisotropic Zeeman interaction in internal/external fields. ^{57}Fe NMR opens up to probe the local susceptibility (hyperfine field), the dynamic susceptibility (spin lattice relaxation rate) and the spin-spin interaction directly "on site". Additionally the NMR line itself (its Fourier transform) provides information about the multiplicity of the Fe sites in the complex helimagnet. ^{57}Fe NMR was performed on crushed single crystals of ^{57}Fe enriched FeGe material between 2-300 K in zero and applied magnetic fields. Phase boundaries in the ordered state are identified and interestingly critical dynamics in the vicinity of these boundaries are obtained from the spin-lattice and spin-spin relaxation rate.

MA 45.8 Thu 17:00 H10

Spindynamics in $CaBaCo_2Fe_2O_7$ under strong geometrical frustration — •Johannes Reim[1], Lars Fritz[2], Martin Valldor[3], and Werner Schweika[1] — [1]JCNS-2 and PGI-4, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany — [3]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany

Recent studies of spin correlations in materials belonging to the swedenborgite compound family ($P6_3mc$)[1] exhibit signs of unusual strong geometric frustration: at low temperatures, indications for quasi 2D spin correlations, spin glass/liquid states, and also rather complex, partly ordered ground states have been observed.[2-3] Several groups have investigated this compound family with different stoichiometry, mainly focusing on solving structural and ground state configurations (f.e. [4]). Since the material characteristics are dominated by the strong magnetic frustration, excitations are very sensitive to small changes in ordering and exchange interactions. We will present neutron inelastic scattering on a single crystal of the compound $CaBaCo_2Fe_2O_7$, that have been obtained from triple axis (PANDA) and thermal time-of-flight scattering (ARCS). The experimental results will be discussed in comparison with theoretical calculations of the phase diagram and the spin dynamics based on nearest neighbor Heisenberg models.

[1] M. Valldor and M. Andersson. Solid State Sci. 4(7):923-931 (2002)
[2] W. Schweika et al. Phys. Rev. Lett., 98(6):067201 (2007)
[3] D. D. Khalyavin et al. Phys. Rev. B, 82(9):094401 (2010)
[4] A. Huq et al. J. Solid State Chem., 179(4):1136-1145 (2006)

MA 45.9 Thu 17:15 H10

Slow magnetic order-order transition in antiferromagnet $Ca_3Co_2O_6$ — •Stefano Agrestini[1], Martin Lees[2], Catherine Fleck[2], Laurent Chapon[3], and Claudio Mazzoli[4] — [1]Max Planck Institut für Chemische Physik fester Stoffe, Dresden, Germany — [2]Physics Department, University of Warwick, Coventry, UK — [3]ILL, Grenoble, France — [4]Politecnico di Milano, Milano, Italia

Time-dependent phenomena play a crucial role in the properties of many magnetic systems, including spin-glasses, single-molecule magnets and superparamagnets. However time-dependent magnetism is not expected to be observed in the presence of long-range magnetic order. Here we challenge this view by reporting the observation of a new time-dependent behavior where a transition from one long-range magnetically ordered state to another occurs in zero magnetic field over a time scale of several hours. We performed an extensive neutron diffraction study of the spin chain system $Ca_3Co_2O_6$ whose step-like magnetization versus magnetic field aroused great interest in the scientific community. Our data show that for T< 14K< T_N =25K the spin-density-wave order observed immediately below T_N, becomes unstable and a commensurate antiferromagnetic phase appears via a very slow transformation process. As the temperature is reduced the characteristic time of the transition process increases rapidly and at low temperatures the magnetic states become frozen. The transition is also noteworthy because the two phases have different propagation vectors. Very rarely transitions between two magnetically ordered phases involve a change of translational symmetry.

MA 45.10 Thu 17:30 H10

The phase diagram of the quantum spin-2 XXZ chain with on-site anisotropy — •Jonas A. Kjäll[1,2], Michael P. Zaletel[1], Roger S. K. Mong[1,3], Jens H. Bardarson[1,4], and Frank Pollmann[2] — [1]Department of Physics, University of California, Berkeley, California 94720, USA — [2]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany — [3]Department of Physics, California Institute of Technology, Pasadena, CA 91125, USA — [4]Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

How the highly quantum mechanical phase diagrams at small spin is connected with the classical (infinite spin) phase diagrams is interesting for many models. We focus on a particular problem, the ground state phase diagram of the quantum spin-2 XXZ chain in the presence of on- site anisotropy. We use a state of the art infinite system density-matrix-renormalization- group (iDMRG) algorithm and show how many challenging phases and phase transitions in quantum spin systems can be accurately detected. Different types of on-site anisotropies are considered, allowing us to establish the validity of the following statements: One, the spin-2 model can be tuned into a phase which is equivalent to the "topologically nontrivial" spin-1 Haldane phase. Two, the spin-2 Haldane phase at the isotropic Heisenberg point is adiabatically connected to the "trivial" large-D phase, with a continuous change of the Hamiltonian parameters. Furthermore, we study the spin-3 XXZ chain to help explain the development of the classical phase diagram.

MA 45.11 Thu 17:45 H10

Investigation of the electronic structure of Cr using the 2D-ACAR technique — •Hubert Ceeh[1], Josef-Andreas Weber[1], Michael Leitner[2], Christoph Hugenschmidt[1,2], Liviu Chioncel[3], and Peter Böni[1] — [1]Technische Universität München, Physik Department E21, D-85748 Garching, Germany — [2]FRM II, Technische Universität München, D-85747 Garching, Germany — [3]University of Augsburg, Theoretical Physics III, D-86135 Augsburg, Germany

Almost all properties of a material are defined by its electronic structure. For a metal, the most important characteristic is the Fermi surface, defining the boundary between occupied and unoccupied states in reciprocal space. The traditional experimental method for studying the Fermi surface is the de Haas-van Alphen effect, which is limited to low temperatures, and therefore cannot be utilized for the study of paramagnetic Cr above the Néel temperature of Cr is 311 K. For this reason, we applied the 2D-ACAR (Angular Correlation of Positron Annihilation Radiation) technique to investigate the electronic structure of both, the paramagnetic and the anti-ferromagnetic phase of Cr. We present the key features of our 2D-ACAR spectrometer and discuss the measurements on the pure metal system Cr, which are also compared with first principle band structure calculations.
This project is funded by the Deutsche Forschungsgesellschaft (DFG) within the Transregional Collaborative Research Center TRR 80 "From electronic correlations to functionality"

MA 45.12 Thu 18:00 H10

ARPES insight into the electronic and magnetic properties of $EuRh_2Si_2$ — •Alla Chikina[1], Silvia Seiro[3], Marc Höppner[1,2], Monika Güttler[1], Steffen Danzenbächer[1], Kurt Kummer[1,4], Yuri Kucherenko[5], Christoph Geibel[3], Ming Shi[6], Luc Patthey[6], Sergey Molodtsov[7], Clemens Laubschat[1], and Denis Vyalikh[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, D-01062, Germany — [2]Max-Planck Institut für Festkörperphysik, Heisenbergstr. 3,D-70569 Stuttgart, Germany — [3]Max-Plank-Institut für Chemische Physic fester Stoffe, Nöthnitzer Straß e 40, D-01187 Dresden, Germany — [4]European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble Cedex, France — [5]Institute for Metal Physics, National Academy of Sciences of Ukraine, UA-03142 Kiev, Ukraine — [6]Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen-PSI, Switzerland — [7]European XFEL GmbH, Albert-Einstein Ring 19, D-22671 Hamburg, Germany

Eu-based intermetallics exhibit interesting low-temperature physics, covering magnetism and mixed-valent behaviour due to delicate interplay between localized 4f and conduction electrons. By doing the photoemission (ARPES) experiments and supplementing them by LDA-based slab- and bulk- band structure calculations, we perform the comprehensive analysis of the electronic and magnetic properties of divalent $EuRh_2Si_2$ system. In the present work we will discuss f-d hybridization phenomena as well as the modification of the electronic structure upon the phase transition from paramagnetic into the antiferromagnetic phase.

MA 45.13 Thu 18:15 H10

Magnetization reversal in Nd-Fe-B based nanocomposites as seen by magnetic neutron scattering — •Jens-Peter Bick[1], Dirk Honecker[1], Frank Döbrich[1], Kiyonori Suzuki[2], Elliot Gilbert[3], Henrich Frielinghaus[4], Joachim Kohlbrecher[5], Jorge Gavilano[5], Edward Forgan[6], Ralf Schweins[7], Peter Lindner[7], Rainer Birringer[8], and Andreas Michels[1] — [1]University of Luxembourg, Luxembourg — [2]Monash University, Australia — [3]ANSTO, Australia — [4]JCNS, Germany — [5]PSI, Switzerland — [6]University of Birmingham, United Kingdom — [7]ILL, France — [8]Universität des Saarlandes, Germany

We have studied the magnetization-reversal process of a $Nd_2Fe_{14}B/Fe_3B$ nanocomposite using small-angle neutron scattering. Based on the computation of the autocorrelation function of the spin misalignment we have estimated the characteristic size l_C of spin inhomogeneities around the $Nd_2Fe_{14}B$ nanoparticles. The quantity l_C approaches a constant value of about 12.5 nm ($\sim$ average $Nd_2Fe_{14}B$ particle radius) at 14 T and takes on a maximum value of about 18.5 nm at the coercive field of -0.55 T. The field dependence of l_C can be described by a model that takes into account the convolution relationship between the nuclear and magnetic microstructure.

MA 45.14 Thu 18:30 H10

Fictitious excitations in the classical Heisenberg antiferromagnet on the kagome lattice — •Stefan Schnabel[1] and David P. Landau[2] — [1]Universität Leipzig — [2]University of Georgia, USA

In the last decades the classical Heisenberg antiferromagnet on the kagome lattice has been subject of a number of theoretical and numerical studies and today its behavior is widely understood. A prominent feature is 'ordering by disorder' meaning the entropy-driven formation of a highly degenerate coplanar state at low temperature. There remain, however, a few open questions. For the coplanar regime analytical investigations predict an acoustic branch of spin waves, while a recent numerical study [1] using standard spin dynamics techniques suggests the existences of additional optical modes. We show how this discrepancy arises from different descriptions of the system and demonstrate that the structure of the low-temperature state causes shifts in Fourier space, thus creating a fictitious optical branch. Furthermore, we applied an advanced Monte Carlo method in combination with spin dynamics simulations of high precision and found very good agreement with the theoretical results regarding the dynamic behavior at low temperatures.

[1] J. Robert, B. Canals, V. Simonet, and R. Ballou, Phys. Rev. Lett. **101**, 117207 (2008).

[2] S. Schnabel and D. P. Landau, Phys. Rev. B **86**, 014413 (2012).