MA 5 Spinstrukturen und magnetische Phasenübergänge

Zeit: Freitag 10:30–13:15 Raum: TU EMH225

MA 5.1 Fr 10:30 TU EMH225

Oscillatory Curie Temperature in Ultrathin Ferromagnets: Experimental Evidence — •C. Rüdt, A. Scherz, and K. Baberschke — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D–14195 Berlin

We determined the Curie temperature T_C for 2-3 monolayers of Co/Cu(100) as a function of the Cu-cap thickness d_{Cu} by means of the initial *ac* susceptibility $\chi_{ac}(T)$ *in situ* in UHV. We found an oscillatory $T_C(d_{Cu})$ in agreement with theoretical predictions [1]. The oscillation of T_C has been observed for more than two full oscillation periods for the first time in the range of 1 ML $\leq d_{Cu} \leq$6 ML. For that purpose films with a fixed Co thickness and variable Cu cap thickness (evaporated step–by–step) have been prepared. In contrast to theory [1] the oscillation amplitude ΔT_C is only a few Kelvin. This can be understood in terms of realistic interlayer exchange parameters [2]. Furthermore, the quantum–well–like oscillatory behavior is superimposed by a monotonic reduction of T_C.

Supported by the DFG (Sfb 290, TP A2).

[1] M. Pajda *et al.*, Phys. Rev. Lett. **85**, 5424 (2000)
[2] C. Rüdt *et al.*, J. Magn. Magn. Mater. (Letter to the Editor) (2004), in print

MA 5.2 Fr 10:45 TU EMH225

Investigation of the topography and the magnetic structure of reconstructed Mn films on Fe(001) — •C. L. Gao, U. Schlickum, W. Wulfhekel, and J. Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle

It is well known that Mn grows layer-by-layer on Fe(001) up to about 15 to 20 monolayers at a substrate temperature of about 100°C. Mn is a topological antiferromagnet thus, the coupling within a Mn atomic layer is ferromagnetic while adjacent layers are coupled antiferromagnetically to each other. The layer-wise antiferromagnetic order of neighbored Mn layers was studied on the nanoscale with an in-plane spin-polarized scanning tunneling microscope (Sp-STM) [1]. In additions, three dimensional islands were observed. In this contribution, we focus the topographic and magnetic behavior of these islands. Their typical height is between 0.8 nm and 3 nm. The surface atoms of the Mn islands are reconstructed into a periodic pattern of parallel stripes. An antiferromagnetic order of the reconstructed surface atoms was observed.

[1] U. Schlickum, N. Janke-Gilman, W. Wulfhekel, and J. Kirschner, Phys. Rev. Lett. 92, 107203 (2004).

MA 5.3 Fr 11:00 TU EMH225

Spin reorientation in high magnetic field and the Co-Gd exchange field in $GdCo_5$ — •Michael Kuzmin[1], Yuri Skourski[1], Dieter Eckert[1], Manuel Richter[1], Karl-Hartmut Müller[1], Konstantin Skokov[2], and Irina Tereshina[3] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung, IFW Dresden, PF 270116, D-01171 Dresden — [2]Faculty of Physics, Tver State University, 33 Gelabova Str., 170002 Tver, Russia — [3]Baikov Institute of Metallurgy and Materials Science RAS, Leninskii Pr. 49, 119991 Moscow, Russia

An upturn in the high-field magnetization curve of a $GdCo_5$ single crystal is observed at about 46 T, which is interpreted as the onset of a process of spin reorientation from the ferri- towards ferromagnetic structure via an intermediate canted phase. This enables us to evaluate the Co-Gd exchange field in $GdCo_5$ as $B_{TR} = 233 \pm 12$ T. This value is very close to the total exchange field on Gd, $B_R = 236 \pm 8$ T, known from earlier inelastic neutron experiments. The difference, $B_{RR} = B_R - B_{TR}$, is attributed to the Gd-Gd exchange interaction. Its smallness provides solid experimental justification for neglecting the 4f-4f exchange in 3d-4f hard magnetic materials. A full-potential density-fuctional calculation of B_{TR} has been carried out using a new approach within the fixed-spin-moment (FSM) technique. The calculated value, $B_{TR} = 258$ T, is 11% too high, most likely because the FSM formalism disregards orbital magnetic moments.

MA 5.4 Fr 11:15 TU EMH225

Fermifläche und Valenzbandstruktur von ferromagnetischen Gd-, Tb- und Dy-Filmen — •K. M. Döbrich[1], J. E. Prieto[1], K. Rossnagel[2], A. Bostwick[2], E. Rotenberg[2], G. Kaindl[1] und K. Starke[1] — [1]Fachbereich Physik, Freie Universität Berlin — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, U.S.A.

Die schweren Lanthanide Gd, Tb und Dy weisen ein *hcp* Kristallgitter mit drei Valenzelektronen pro Atom auf, weswegen ihre Bandstrukturen und Fermiflächen in der paramagnetischen Phase sehr ähnlich sind. Die Besetzung der $4f$-Schale nimmt von Gd über Tb zu Dy um jeweils ein Elektron zu, womit eine Abnahme des Gesamtspins pro Atom und damit der Austauschaufspaltung einhergeht. Dies führt in der ferromagnetischen Phase zu signifikanten Unterschieden in den Bandstrukturen und Fermiflächen. Da die magnetischen $4f$-Momente so stark lokalisiert sind, daß ihre direkte Wechselwirkung vernachlässigt werden kann, erfolgt die magnetische Kopplung benachbarter Atome über die itineranten Valenzelektronen ($RKKY$-Wechselwirkung). Unterschiede in der Bandstruktur und Fermifläche haben daher entscheidenden Einfluß auf die Ordnungstemperaturen und magnetischen Phasen der schweren Lanthanide.

Unsere winkelaufgelösten Photoemissionsmessungen an epitaktisch auf W(110) aufgedampften Gd-, Tb- und Dy-Filmen zeigen Unterschiede in Bändern und Fermifläche bei 30 K. Ein Vergleich mit neuen theoretischen Rechnungen erzielt gute Übereinstimmung.

MA 5.5 Fr 11:30 TU EMH225

Magnetic X-Ray Scattering at the Lanthanide M_5 Resonance — •H. Ott[1,2], C. Schüssler-Langeheine[2], E. Schierle[1], V. Leiner[3,4], H. Zabel[3], G. Kaindl[1], and E. Weschke[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin — [2]II. Physikalisches Institut, Universität zu Köln — [3]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum — [4]Institut Laue-Langevin, Grenoble, France

The quantitative analysis of magnetic x-ray scattering from thin Ho-metal films at the lanthanide M_5 resonance reveals magnetic scattering length f_{mag} up to $200r_0$, i.e. of the same order of magnitude as theoretically predicted. The photon-energy dependence of first- and second-order magnetic satellites allows a straightforward identification of circular and linear dichroic contributions to the scattering length. In a few examples we demonstrate the potential of the method for studies of complex magnetic structures in ultrathin films.

MA 5.6 Fr 11:45 TU EMH225

Angular dependent absorption spectroscopy of a de-twinned $DyBaCo_2O_{5.5}$ single crystal — •Myrsini Lafkioti[1], Stefan Gold[1], Eberhard Goering[1], Gisela Schütz[1], Joachim Deisenhofer[2], and Peter Lemmens[3] — [1]Max-Planck-Institut für Metallforschung, 70569 Stuttgart — [2]Lst. für Eperimentalphysik V, Uni-Augsburg, 86159 Augsburg — [3]Inst. fuer Halbleiterphysik und Optik, TU Braunschweig, 38106 Braunschweig

The Perovskite $DyBaCo_2O_{5.5}$ exhibits a very rich phase diagram including two different paramagnetic, a ferromagnetic, and an antiferromagnetic phase as a function of temperature[1]. In addition to these unusual properties, the system exhibits a very pronounced and strong magnetocrystalline anisotropy, with the easy axis along the crystallographic a-axis[2]. We will show detailed angular and temperature dependent X-ray magnetic circular dichroism and nonmagnetic linear polarized absorption spectroscopy results at the Co $L_{2,3}$ and O K edges, performed on a de-twinned single crystal. A clear and quantitative correspondence between the microscopic and macroscopic magnetic behavior has been found. O K edge spectra reveal angular dependent variations, which give insight to the orbital character of the unoccupied states. Our results provide detailed information about the microscopic physics behind the observed unusual and also technical very promising properties. [1] A. Maignan *et al.*, Journal of Solid State Chemistry **142**, 247 (1999). [2] A. A. Taskin *et al.*, Phys.Rev.Lett. **90**, 227201-1 (2003).

MA 5.7 Fr 12:00 TU EMH225

Magnetism of weakly doped spin chains in $La_5Ca_9Cu_{24}O_{41}$ — •R. Leidl[1], R. Klingeler[2], B. Büchner[2], W. Selke[1], and M. Holtschneider[1] — [1]Institut für Theoretische Physik, RWTH Aachen, 52056 Aachen, Germany — [2]IFW Dresden, PF 270116, 01171 Dresden, Germany

Recent experiments revealed rather surprising magnetic properties of weakly hole doped spin chains in the "telephone number" compound $La_5Ca_9Cu_{24}O_{41}$. In particular, at low magnetic fields a small anomaly, indicating a phase transition, in the susceptibility curves (and other quantities) is observed, followed by a rather broad maximum at higher fields where one would usually expect a spin-flop transition. In an effort to (partially) understand these observations we study a classical anisotropic Heisenberg antiferromagnet with spinless holes, using mainly Monte Carlo simulations. We show that a broad maximum in the susceptibility can be caused by a disorder effect, originating in the influence of randomly distributed, immobile holes on the spin-flop transition.

MA 5.8 Fr 12:15 TU EMH225

Substitution of Manganese in electron-doped manganites — •Uwe Amann[1,2], Clemens Ritter[2], Dietmar Hohlwein[1,3], and Jörg Ihringer[1] — [1]Universität Tübingen, Institut für Angewandte Physik, Auf der Morgenstelle 10, 72076 Tübingen, Germany — [2]Institut Laue-Langevin, 6, Rue Jules Horowitz, B.P. 156, 38042 Grenoble, France — [3]Hahn-Meitner-Institut, Glienicker Straße 100, 14109 Berlin, Germany

As part of a systematic investigation[1,2,3] of substitution effects of Manganese by other trivalent atoms, we investigated the temperature-dependant evolution of the magnetic moments in the CMR-compound $Y_{0.1}Ca_{0.9}Ga_{1-x}Mn_xO_3$ for x = 0.0, 0.02, 0.04.

For temperatures above the Neel temperature the samples display monophase *Pnma* structure. With the onset of magnetic ordering, the system splits into at least two phases, an antiferromagnetic G-type ordered matrix into which ferromagnetic regions (FM) are embedded and a second, monoclinic antiferromagnetic (M-AFM) phase in nuclear space group $P2_1/m$.

Substitution with different ions acts differently on the magnetic structure: Iron inhibits the formation of FM and M-AFM phases, but doesn't disturb the magnetic exchange paths, so there is no change in phase transition temperature. Gallium on the other hand, without magnetic moment, disturbs the exchange paths, shifting the phase transition to lower temperatures.

[1]Th. Lottermoser, Nature 430 (2004), 541-544.
[2]U. Amann et al., Z. Krist, Suppl. 18 (2000), 79
[3]K. Hagdorn et al.,Eur. Phys. J. B, 11 (1999), 243

MA 5.9 Fr 12:30 TU EMH225

Giant Magnetoelectric Response in Multiferroic Manganites due to Rare Earth Ordering — •Thomas Lonkai[1,2], Uwe Amann[1,3], Manfred Fiebig[4], Dana Tomuta[5], Dietmar Hohlwein[1,2], and Jörg Ihringer[1,2] — [1]Institute for Applied Physics, University of Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany — [2]Hahn-Meitner-Institut, Berlin, Glienicker Str. 100, 14109 Berlin, Germany — [3]Institut Laue-Langevin, 6 Rue Jules Horowitz, BP 156 - 38042 Grenoble Cedex 9, France — [4]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany — [5]Kamerlingh Onnes Laboratory, Leiden University, P.O. Box 9504, 2300 RA Leiden, The Netherlands

We analysed the zero field magnetoelectric phase transitions in hexagonal $ErMnO_3$ and $HoMnO_3$ by second harmonic generation, measurements of the specific heat, and neutron powder and single crystal diffraction. The magnetic phase transitions from $P6'_3cm'$ to $P63cm$ ($HoMnO_3$) and $P6'_3c'm$ to $P6_3c'm'$ ($ErMnO_3$) were determined by second harmonic generation. Specific heat data shows the magnetoelectric contribution to the free energy. Refinements of the neutron diffraction data, based on the results of the known symmetries, determines the displacements of the atomic positions and the magnetic ordering process.

Our experiments shows the importance of the rare earth ordering process in the magnetoelectric phase transitions in hexagonal manganites. Due to the large magnetic moment of Er^{3+} and Ho^{3+} the magnetoelectric contribution to the free energy is large enough to trigger an electric phase transition of the O-Mn-O-axis of the MnO_5 coordination polyhedra.

MA 5.10 Fr 12:45 TU EMH225

Optische und magnetooptische Eigenschaften von UN-Einkristallen — •M. Marutzky[1], U. Barkow[1], R. Troć[2] und J. Schoenes[1] — [1]Inst. Halbleiterphysik u. Optik und Hochmagnetfeldanlage, TU BS, Mendelssohnstr. 3, 38106 Braunschweig — [2]Inst. Low Temperature and Structure Research, Polish Academy of Sciences, P.O. Box 1410,50-950 Wrocław

UN ist eine Verbindung mit im Vergleich zu den schwereren Uranpniktiden relativ delokalisierten 5f-Elektronen. Sie kristallisiert in der NaCl-Struktur und ordnet antiferromagnetisch bei $T_N = 50$ K. Bereits in den 1980ern wurde UN mit großem Interesse untersucht. Im Gegensatz zu den schwereren Uranpniktiden wurden die optischen und magnetooptischen Eigenschaften von UN-Einkristallen noch nicht untersucht. Wir haben die optischen Konstanten im Bereich von 1 bis 10 eV aus Ellipsometrie bestimmt, bei höheren Energien dabei am VUV-Ellipsometer am BESSY II. Der polare Kerreffekt wurde an der Hochmagnetfeldanlage der TU Braunschweig von 1 bis 5 eV bei 8,2 T nahe T_N untersucht. Wir finden Kerrdrehungen bis zu 0,2°. An die gemessene optische Leitfähigkeit wird ein Drude-Lorentzmodell angepasst und es werden die Nichtdiagonal-Elemente der optischen Leitfähigkeit berechnet. Mit Hilfe dieser Ergebnisse werden Rückschlüsse auf die elektronische Struktur von UN gezogen und diese mit der der übrigen Uranpniktide verglichen. Wir danken der Gruppe von N. Esser, insbesondere C. Cobet, für das Ermöglichen von Messungen am BESSY II und dem BMBF für finanzielle Unterstützung.

MA 5.11 Fr 13:00 TU EMH225

Neutron Crystal Field Spectroscopy on the Antiferroquadrupolar system $TmGa_3$ — •Michael Banks[1], Reinhard K Kremer[1], Danny Mannix[2], and Amir Murani[3] — [1]MPI-FKF, 70569 Stuttgart — [2]ESRF Grenoble, CEDEX 9 — [3]ILL Grenoble, CEDEX 9

At room temperature $TmGa_3$ crystallizes with the cubic Cu_3Au structure type. At low temperature it undergoes two first order phase transitions, ascribed to a antiferroquadrupole (AFQ) ordering at 4.29K and an antiferromagnetic (AFM) transition at 4.26K. The Crystal Electric Field (CEF) ground state of the trivalent Tm^{3+} ($4f^{12}$, $J = 6$) in the cubic crystal field environment given by an earlier study [1] to ascertain the CEF parameters (in the Lea-Leask-Wolf scheme [2]) arrived at values of x=0.32, W=1.03K with a $\Gamma_5^{(1)}$ ground state separated by the first excited state Γ_3 at 2.5meV. To investigate possible quadrupolar splittings of the CEF levels we performed inelastic neutron scattering. Surprisingly, our level scheme suggests a Γ_2 singlet CEF ground state with the first excited state being a Γ_1 singlet and $\Gamma_5^{(2)}$ triplet at $\sim$0.5 meV, which are almost degenerate, adverse to previous findings [1].

[1] P. Morin et al., J. Mag. Mag. Mat., 66, 345 (1987)
[2] K.R. Lea et al., J. Phys. Chem. Solids, 23, 1381 (1962)