MA 32: Spin Structures and Magnetic Phase Transitions

Time: Wednesday 15:00–17:45 Location: EB 202

MA 32.1 Wed 15:00 EB 202

Magnetic phase transition and anisotropy in Mn_3GaC — •Moritz Riebisch, Mehmet Acet, Ralf Meckenstock, Horst Zähres, and Michael Farle — Universität Duisburg-Essen, Fakultät für Physik, AG Farle

A new setup for temperature and frequency dependent magnetic resonance measurements at high magnetic fields up to 12 T was built to study the field-induced magnetic phase transition and transitional hysteresis of the antiperovskite compound Mn_3GaC. The magnetic phase transition at $T_t \approx 165$ K of a powdered sample of Mn_3GaC was studied with temperature dependent FMR at 9.2 GHz. A field-hysteresis between 160 and 145 K in the FMR measurements indicates the field-induced transition between the antiferromagnetic ground state and the ferromagnetic phase. In the ferromagnetic phase, aligned and non-aligned resonance modes are measured as a function of temperature and frequency. Frequency dependent measurements yield an estimation of the magnetocrystalline anisotropy. The value of K4 is in the order of -100kJ/m^3 at $T = 176\,\text{K}$.

Financial support by DFG is acknowledged.

MA 32.2 Wed 15:15 EB 202

Spin freezing and spin dynamics in the re-entrant spin glass $Cr_{1-x}Fe_x$ — •Steffen Säubert[1,3], Georg Benka[1], Jonas Kindervater[1], Andreas Bauer[1], Julia N. Wagner[4], Wolfgang Häussler[3], Olaf Holderer[3], Stephen M. Shapiro[5], Christian Pfleiderer[1], and Peter Böni[2] — [1]Lehrstuhl für Topologie korrelierter Systeme, Technische Universität München, Garching, Germany — [2]Lehrstuhl für Neutronenstreuung, Technische Universität München, Garching, Germany — [3]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Garching, Germany — [4]Karlsruher Institute for Technology, IAM-WK, Eggenstein-Leopoldshafen, Germany — [5]Brookhaven National Laboratory, Department of Physics, Upton, USA

$Cr_{1-x}Fe_x$ shows reentrant spin glass behaviour as the ground state changes from antiferromagnetic to ferromagnetic order with increasing iron concentration x [1, 2]. We report magnetisation measurements, neutron depolarisation imaging (NDI) and neutron resonance spin-echo (NRSE) spectroscopy for a wide range of concentrations x. Our measurements provide an unprecedented combination of microscopic information on the spin dynamics and spin freezing on multiple length and time scales.

[1] S. K. Burke et al., J. Phys. F: Met. Phys. **13** (1983) 45 1-470
[2] S. M. Shapiro et al., Phys. Rev. B **24** (1981), 6661

MA 32.3 Wed 15:30 EB 202

Quantum-mechanical study of clean and segregated Σ5(210) grain boundaries in Ni_3Al — •Martin Friák[1,2], Monika Všianská[2,1], and Mojmír Šob[2,1,3] — [1]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic — [2]Central European Institute of Technology, CEITEC MU, Masaryk University, Brno, Czech Republic — [3]Department of Chemistry, Faculty of Science, Masaryk University, Brno, Czech Republic

Grain boundaries (GBs) represent an important class of two-dimensional extended defects and macroscopic strength of polycrystalline materials depends strongly on their cohesion. It is known that impurities in ppm concentration can drastically change material properties. After our previous study of segregation trends of sp elements in Ni [1], we extend our research to a binary intermetallic compound, Ni_3Al. We employ quantum-mechanical methods to study the energetics, magnetism, segregation and strengthening/embrittling tendencies at the Σ5(210) GB. We simulate two different interface stoichiometries of the clean Ni_3Al Σ5(210) GB and that one with both Ni and Al atoms present at the interface is found to have a lower energy than that with only Ni atoms. For Si, Ga, Ge, As, Se, In, Sn, Sb and Te segregated to Ni_3Al Σ5(210) GB and free (210) surfaces, we perform the relaxation of the geometric configurations with and without impurities and analyze the effect of impurities on the distribution of magnetic moments.

[1] M. Všianská and M. Šob, Prog. Mat. Sci. 56 (2011) 817, and Phys. Rev. B 84 (2011) 014418.

MA 32.4 Wed 15:45 EB 202

Neutron study of the field-dependant spin structure of nanocrystalline and coarse-grained holmium — •Daniel Kaiser[1], Philipp Szary[1], Jens-Peter Bick[1], Andre Heinemann[2], Charles Dewhurst[3], and Andreas Michels[1] — [1]Physics and Materials Science Research Unit, University of Luxemburg — [2]HZG, Geesthacht, Germany — [3]Institute Laue-Langevin, Grenoble, France

We present the results of magnetic-field-dependant small-angle neutron scattering (SANS) measurements on nanocrystalline (nc) and coarse-grained (cg) polycrystalline holmium. At 50 K, single-crystalline holmium exhibits a series of complicated spin structures with increasing applied magnetic field, ranging from a simple antiferromagnetic helix, to a helifan-3/2, to a fan, and finally to a ferromagnetic structure. While the transitions between these different structures are discrete in the defect-free single-crystalline case, we observe for nc and cg holmium the emergence of periodic structures with a continuously changing wavelength. Moreover, a superposition of several structures at the same field was found for both materials.

MA 32.5 Wed 16:00 EB 202

Structural, magnetic and magneto-optical properties of Mn2NiSn and Fe-Ni-Sn compounds — Michaela Tomíčková[1], Lukáš Beran[2], Petr Cejpek[2], Jaromír Kopeček[3], Oleg Heczko[3], Dominik Legut[1], Rastislav Varga[4], Václav Holý[2], Martin Veis[2], and •Jaroslav Hamrle[1] — [1]VSB-Technical University of Ostrava, Czech Republic — [2]Charles University in Prague, Czech Republic — [3]Institute of Physics, ASCR, Prague, Czech Republic — [4]UPJŠ Košice, Slovakia

Heusler compounds are well-known as exceptionally tunable materials by suitable element substitution. Here we present study of structural (XRD, SEM, EDX), magnetic (SQUID) optical and magneto-optical (ellipsometry, MOKE spectroscopy) properties of Mn_2NiSn cubic Heusler and Fe-Ni-Sn hexagonal compounds. Physical properties were studied with respect to the material composition and post deposition treatment. The samples were prepared by repeated arc melting of stoichiometric amounts of high-purity elements in argon atmosphere. Selected alloys were then subsequently annealed at 1200°C, however effect of annealing was found negligible. In case of Fe-Ni-Sn, only hexagonal ($P6_3$/mmc) $Fe_2Ni_3Sn_3$ was found to exhibit ternary phase. Spectral dependencies of complete permittivity tensor of studied materials in the photon energy range from 1.5 to 5 eV were deduced from ellipsometric and MOKE measurements. These dependencies were confronted with ab-initio calculations to obtain the information about the electronic structure of studied compounds. Supported by Grant Agency of Czech Republic 13-30397S.

15 min. break

MA 32.6 Wed 16:30 EB 202

Reversible processes in minor loop hysteresis at the first-order magnetostructural transition in NiMnX (X=In, Sn) — •Franziska Scheibel[1], Tino Gottschall[2], Michael Farle[1], and Mehmet Acet[1] — [1]Faculty of Physics and CENIDE Universität Duisburg-Essen, Duisburg, Germany — [2]Material Science Technische Universität Darmstadt, Darmstadt, Germany

One key factor for efficient magnetic refrigeration is the reversibility of the adiabatic temperature-change ΔT when the external magnetic field is reversed. Even if ΔT is large in the range of a first-order magnetostructural transition (FOMST), the thermal hysteresis of the transition can limit its reversibility [1-2]. Materials with sufficiently narrow thermal hysteresis shows a reversible ΔT in a minor loop of the transition. NiMnX (X=Sn, In) Heusler alloys show a FOMST from a low temperature martensite state with low magnetization to a high temperature austenite state with a higher magnetization. The transition temperatures are around room temperature and the hysteresis is smaller than 10 K. To understand the reversible processes in the minor loops adiabatic ΔT and magnetostriction been measured simultaneously in an externally applied field up to 5 T. The magnetostriction behavior of the material is directly related to the volume ratio of matrensite- to austenite phase.

Work supported by the Deutsche Forschungsgemeinschaft (SPP 1599).

[1] I. Titov et al., J. Appl. Phys. **112**, 073914 (2012)
[2] J. Liu et al., Nature Materials **11**, 620-626 (2012)

MA 32.7 Wed 16:45 EB 202

Hydrostatic Pressure Investigation on the Magnetic and Structural Properties of the Quantum-Spin-Chain CuAs2O4 — •Kevin Caslin[1], Reinhard Kremer[1], Karl Syassen[1], Fereidoon Razavi[2], Michael Hanfland[3], Mike Whangbo[4], and Elijah Gordon[4] — [1]Max Planck Institute Stuttgart — [2]Brock University — [3]ESRF — [4]North Carolina State University

$CuAs_2O_4$ (Trippkeite) is a $S = 1/2$ quantum-spin-chain system with competing ferromagnetic nearest-neighbor (NN) and antiferromagnetic next-nearest-neighbor (NNN) spin-exchange interactions which undergoes long-range ferromagnetic ordering below 7.4 K. We have investigated the pressure dependence of the magnetic and structural properties of the $CuAs_2O_4$ by single-crystal synchrotron x-ray diffraction, Raman spectroscopy and SQUID magnetometry under hydrostatic pressure. Precise structural parameters gained from the single crystal x-ray structure determination under hydrostatic pressure have been used for detailed density functional calculations of the spin-exchange interactions. Furthermore, we have correlated the spin-exchange constants to the magnetic properties measured under hydrostatic pressure. Up to approximately 9 GPa we observe a significant reduction of the Jahn-Teller elongations of the distorted CuO_6 octahedra. Above approximately 9 GPa a structural phase transition occurs which leads to modifications of the crystals structure driving both NN and NNN spin-exchange constants to the ferromagnetic regime, thus, removing the magnetic frustration.

MA 32.8 Wed 17:00 EB 202

Photoluminescence monitoring of magnetic phase transitions in CuB_2O_4 — •Dennis Kudlacik[1], Jörg Debus[1], Roman V. Pisarev[2], Dmitri R. Yakovlev[1,2], and Manfred Bayer[1,2] — [1]Experimentelle Physik 2, TU Dortmund, Dortmund, Germany — [2]Ioffe Physical-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia

Copper metaborate CuB_2O_4 comprises two sublattices with different magnetic orderings. At low temperatures below $T_N = 21K$, CuB_2O_4 demonstrates an antiferromagnetic ordering and a rich magnetic phase diagram with several phase transitions [1]. Commensurate and incommensurate magnetic orderings are observed as a result of intra-sublattice and inter-sublattice mutual interactions. The study of these interactions for the various magnetic phases of the sublattices shall provide highly promising insights into properties of different kinds of collective spin interactions. In that context, we report on the monitoring of the magnetic phase transitions via photoluminescence (PL). The intensity, linewidth as well as energy of the sublattice PL indicate changes in the magnetic ordering. Hereby, not only the ambient temperature but also the optical pumping intensity can induce a magnetic phase transition. During the decay time of the 4b-sublattice PL of several hundreds of μs, the magnetic phase transitions could be followed in the time domain highlighting the dynamics between the spin, electron and phonon systems.

[1] R. V. Pisarev et al., Phys. Rev. B 88, 024301 (2013).

MA 32.9 Wed 17:15 EB 202

High-frequency electron spin resonance studies on the antiferromagnetic phase of $A_3Ni_2SbO_6$ (A = Li, Na) — Jaena Park[1], •Changhyun Koo[1], Michael Tzschoppe[1], Maria A. Evstigneeva[2], Vladimir B. Nalbandyan[2], Elena A. Zvereva[3], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany. — [2]Chemistry Faculty, Southern Federal University, Rostov-na-Donu, Russia. — [3]Faculty of Physics, Moscow State University, Moscow, Russia.

High-frequency electron spin resonance (HF-ESR) and static magnetization studies have been used to study the antiferromagnetically ordered phase in the layered honeycomb antimonates $A_3Ni_2SbO_6$ (A = Li, Na). Antiferromagnetic resonance (AFMR) branches are observed below Neel temperature of both compounds, 15 K and 17 K, respectively, and the frequency-magnetic field phase diagram of the AFMRs is constructed. Above the Neel temperature, all AFMR branches merge to a single resonance mode. The frequency field diagram allows reading off the zero-field splitting which amounts to about 200 GHz and 360 GHz, respectively. The spin-flop field is extracted both from the static magnetization and the AFMR data. Analyzing the AFMR modes by means of spin wave theory provides estimates of the exchange field and of the magnetic anisotropy in the antiferromagnetic phase of both compounds.

MA 32.10 Wed 17:30 EB 202

Magnetic properties of a new phase of $MnSb_2O_6$ — •Johannes Werner[1], Michael Tzschoppe[1], Changhyun Koo[1], Vladimir B. Nalbandyan[2], Alexey Yu. Nikulin[2], Elena A. Zvereva[3], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany — [2]Chemistry Faculty, Southern Federal University, Rostov-na-Donu, Russia — [3]Moscow State University, Moscow, Russia

Magnetic properties of a new, layered, trigonal ($P\overline{3}1m$) form of $MnSb_2O_6$ were investigated by means of magnetic susceptibility and high-frequency electron spin resonance (HF-ESR) measurements. The magnetic susceptibility at high temperatures follows the Curie-Weiss law, with a Weiss temperature of $\Theta = -17$K, indicating antiferromagnetic interactions. Indeed, long range antiferromagnetic order appears at $T_N = 9$K. In addition, the data imply weak ferromagnetism below $T_1 = 41.5$K. Based on the magnetic susceptibility and specific heat data the magnetic phase diagram of the new $MnSb_2O_6$ form is constructed. The spin-flop field of 1T in the antiferromagnetically ordered phase signals only a small anisotropy which is confirmed by our HF-ESR data. In addition, there is a phase boundary in the non-spin-flopped phase separating two regions of antiferromagnetic order. At this boundary, there are only negligible entropy changes. In HF-ESR, the antiferromagnetic resonance mode is observed and spin wave theory is applied to model the results.