MA 60: Magnetic Materials: Applications and Multielement Bulk Materials

Time: Friday 9:30–12:00 Location: HSZ 101

MA 60.1 Fri 9:30 HSZ 101

Magnetic e-skin enables both touch and non-touching sensitivities — •J. Ge, X. Wang, G. S. Canon Bermudez, J. Fassbender, and D. Makarov — Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany

Humans can interact with unstructured surroundings precisely with the aid of ears, eyes, and skin. Ears and eyes help humans interact with surrounding objects though a non-touching mode, while human skin provides the touch feeling for humans to sense the temperature of objects, strain and pressure on skin, friction for holding objects, among others. Interest of realizing both touch and non-touching sensing functions of humans is motivated by the promise of creating advanced humanoid robots, biomedical prostheses, surgical electronic gloves and wearable health monitoring devices [1, 2]. Herein we present a magnetic skin that not only is sensitive to pressure, flexion, and strain, but also has the ability to detect the position and movement of magnetic objects in a non-touching sensing mode. The magnetic skin is a stack of a wrinkle GMR sensor layer and a pyramid-structured magnetic foil. The GMR sensor enables the sensing of the movement of remote magnetic objects (non-touching), and distance change between GMR sensor and magnetic foil caused by mechanical deformation make the magnetic skin be sensitive to pressure, stretch and flexion (touch mode). This magnetic skin will possess great potential application in future intelligent products.

1. Z. Q. Ma et al. Science 333, 830-831, (2011). 2. Z. A. Bao et al. Adv. Mater. 25, 5997-6037, (2013).

MA 60.2 Fri 9:45 HSZ 101

Valence state of Sm in Sm-substituted EuO — •Andreas Reisner, Steffen Wirth, Simone G. Altendorf, and Liu Hao Tjeng — Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187, Dresden, Germany

Europium monoxide is a ferromagnetic semiconductor with a Curie temperature of 69 K. It has the rocksalt crystal structure with a lattice constant of 5.14 Å and the Eu is in the stable high-spin divalent state. SmO on the other hand, is a non-magnetic metallic oxide. It has also the rocksalt crystal structure and the lattice constant is 4.94 Å. Interestingly, the Sm is presumably in a mix-valent state (2.9+) as argued from lattice constant considerations [J. M. Leger et *al.*, Inorg. Chem. 19, 2252 (1980); G. Krill et *al*. Solid State Commun. 33, 351 (1980)]. The question now arises what the valence of the Sm will be if it is inserted in the EuO crystal. Considering the larger lattice constant of EuO as compared to SmO, one may expect that the Sm in EuO will have enough room to stabilize even the divalent (and non-magnetic) charge state [D. Kasinathan et *al*., Phys. Rev. B 91, 195127 (2015)].

We have grown thin films of $Sm_xEu_{1-x}O$ using reactive molecular beam epitaxy. Structural analysis verifies the incorporation of Sm into the EuO crystal up to high doping levels of 17 at.%. We will present our *in situ* x-ray photoelectron spectroscopy study as well as our *ex situ* magnetization measurements to unveil the valence of Sm inserted in EuO.

MA 60.3 Fri 10:00 HSZ 101

Interplay of localization and magnetism in (Ga,Mn)As and (In,Mn)As — •Ye Yuan[1], Maciej Sawicki[2], Tomasz Dietl[2,3,4], Manfred Helm[1], and Shengqiang Zhou[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Institute of Physics, Warsaw, Poland — [3]Faculty of Physics, University of Warsaw, Warsaw, Poland — [4]WPI-Advanced Institute for Materials Research, Tohoku University, Sendai, Japan

We examine the role of localization on the hole-mediated ferromagnetism in dilute ferromagnetic semiconductors by combining results of electrical and magnetic studies for Mn-implanted GaAs and InAs. In both materials upon increasing the Mn concentration, a change from an insulating (hopping) regime of conductivity to a metallic-like is accompanied by a gradual build-up of a long-range magnetic coupling and a monotonic increase of the Curie temperature. For the least conducting sample no (global) Curie temperature can be identified, although the observed slow dynamics (superparamagnetic-like) confirms the presence of a ferromagnetic coupling acting only over limited (mesoscopic) distances. Our findings strongly advocate for the heterogeneous model of electronic states at the localization boundary and point to the crucial role of weakly localized holes in mediating efficient spin-spin interactions between diluted spins even on the insulator side of the metal-to-insulator transition. This constitutes a new experimental support for the suggestion that larger p-d coupling results in higher values of TC only in the regime, where hole localization effects are not crucial.

MA 60.4 Fri 10:15 HSZ 101

Electronic and magnetic properties of the 2H-NbS_2 intercalated by 3*d* transition elements — •Sergiy Mankovsky[1], Svitlana Polesya[1], Hubert Ebert[1], and Wolfgang Bensch[2] — [1]Dept. Chemie, Ludwig-Maximilians-Universität München, 81377 München, Germany — [2]Inst. für Anorgan. Chemie, Universität Kiel, 24098 Kiel, Germany

The electronic structure and magnetic properties of the 2H-NbS_2 compound intercalated by 3*d* transition elements, have been investigated by means of the Korringa-Kohn-Rostoker (KKR) method. Magnetic torque calculations demonstrate an easy plane magneto-crystalline anisotropy (MCA) for the $Cr_{1/3}NbS_2$ and $Mn_{1/3}NbS_2$ compounds for their ground state at $T = 0$ K. Going from the Cr and Mn to the Fe intercalated system, the modification of the electronic structure results in a change of the uniaxial MCA from the in-plane to the out-of-plane anisotropy. It is shown, that for $Cr_{1/3}NbS_2$ and $Mn_{1/3}NbS_2$ the in-plane MCA and Dzyaloshinskii-Moriya interactions give rise to a helimagnetic structure along the hexagonal *c* axis; in line with experiment. The negative exchange interactions in the $Fe_{1/3}NbS_2$ compound results in a non-collinear frustrated magnetic structure if the MCA is not taken into account. However, a strong MCA along the hexagonal *c* axis leads – as observed experimentally – to a magnetic ordering referred to as ordering of the third kind.

MA 60.5 Fri 10:30 HSZ 101

Thermal and thermoelectric high-magnetic-field study of the multiband superconductor FeSe — •Stevan Arsenijević[1], Tatsuya Watashige[2], Lars Opherden[1], Shigeru Kasahara[2], Yoshifumi Tokiwa[2], Yuichi Kasahara[2], Takasada Shibauchi[3], Hilbert von Löhneysen[4], Jochen Wosnitza[1], and Yuji Matsuda[2] — [1]Hochfeld-Magnetlabor Dresden (HLD-EMFL), Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany — [2]Department of Physics, Kyoto University, Kyoto 606-8502, Japan — [3]Department of Advanced Materials Science, University of Tokyo, Chiba 277-8561, Japan — [4]Physikalisches Institut, Karlsruhe Institut für Technologie, 76131 Karlsruhe, Germany

We explored the high-magnetic-field behavior of the thermoelectric and thermal-transport coefficients to probe the quasiparticle excitations in the normal and superconducting phase of FeSe. The small and compensated thermoelectric coefficients increase with decreasing temperature (T) due to the T-dependent increase of the charge-carrier mobility and the dominant role of the small hole Fermi-surface pocket. The measured longitudinal and transverse thermal conductivities imply that a highly anisotropic small superconducting gap forms at the electron pocket whereas an isotropic and larger gap forms at the hole pocket. Below 1 K, both thermal conductivities exhibit anomalies at the upper critical field, H_{c2}, and at a constant field H^* around 14 T. These results support the existence of a distinct field-induced superconducting phase above H^* which emerges with a presumed large spin-imbalance of the hole Fermi-surface pocket.

MA 60.6 Fri 10:45 HSZ 101

Epitaxial thin films of Sr_2MnIrO_6 double perovskites — •Supratik Dasgupta, Philipp Komissinskiy, Hongbin Zhang, and Lambert Alff — Institute of Materials Science, Technische Universität Darmstadt, Germany

We present our studies of highly crystalline epitaxial thin films of a 3*d*-5*d* double perovskite Sr_2MnIrO_6 grown by pulsed laser deposition. In this compound, the orbital degeneracy between the t_{2g} and e_g electron states is lifted with the crystal field of the heavy Ir^{4+} cation. Moreover, the t_{2g} levels are split into low-energy $J = 3/2$ and high-energy $J = 1/2$ states due to the strong spin-orbital coupling, resulting in exotic ground states observed previously in other perovskite iridates [1]. The compressively (tensile) strained Sr_2MnIrO_6 films were grown onto LSAT ($SrTiO_3$ and $DyScO_3$) single crystalline substrates.

Magnetic measurements of the Sr_2MnIrO_6 films grown on $SrTiO_3$ reveal T_c =110 K. The observed magnetization values of 0.4 μ_B/f.u. at 5 K can be explained with a Mn antiferromagnetic coupling plus a spin canting due to the tetragonal lattice distortions. The temperature dependence of the Sr_2MnIrO_6 electric resistivity indicates that Sr_2MnIrO_6 is a narrow band-gap insulator.

[1] W. Witczak-Krempa *et al.*, Annu. Rev. Condens. Matter Phys. **5**, 57 (2014).

MA 60.7 Fri 11:00 HSZ 101

Thermal expansion and magnetostriction of single-crystalline $LiFePO_4$ — •Sven Krippendorf, Christoph Neef, Anna Pollithy, Norbert König, and Rüdiger Klingeler — Kirchhoff Institute of Physics, Heidelberg University, Germany

We report thermal expansion and magnetostriction studies in magnetic fields up to 17 T on $LiFePO_4$ single crystals grown by the optical floating zone method. The onset of long range antiferromagnetic order at $T_N = 50.1(5)$ K is associated with pronounced λ-like anomalies of the thermal expansion coefficient α. In addition, there is an extended regime of fluctuations up to ≥ 80 K. We observe an additional anomaly in the linear thermal expansion coefficient of the crystalline b- and c-axis well below T_N which field dependence is studied in detail. Grüneisen analysis reveals it as a new phenomenon which is not of purely magnetic origin and that has not been reported in the literature so far.

MA 60.8 Fri 11:15 HSZ 101

Universal distribution of magnetic anisotropy of impurities in ordered and disordered nanograins — •Attila Szilva[1], Peter Balla[2,3], Olle Eriksson[1], Gergely Zarand[4], and Laszlo Szunyogh[2,5] — [1]Department of Physics and Astronomy, Division of Materials Theory, Uppsala University, Box 516, SE-75120 Uppsala, Sweden — [2]Department of Theoretical Physics, Budapest University of Technology and Economics, Budafoki ut 8, H-1111 Budapest, Hungary — [3]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Hungarian Academy of Sciences, P.O. Box 49, H-1525 Budapest, Hungary — [4]BME-MTA Exotic Quantum Phases *Lendulet* Group, Institute of Physics, Budapest University of Technology and Economics, H-1521 Budapest, Hungary — [5]MTA-BME Condensed Matter Research Group, Budapest University of Technology and Economics, Budafoki u *t 8, H-1111 Budapest, Hungary

We examine the distribution of the magnetic anisotropy experienced by a magnetic impurity embedded in a metallic nanograin. Confinement of the electrons induces a magnetic anisotropy that is large, and can be characterized by five real parameters, coupling to the quadrupolar moments of the spin. For disordered grains they are randomly distributed and, for stronger disorder, their distribution is found to be characterized by random matrix theory. The probability of having small magnetic anisotropies is suppressed below a characteristic scale, leading to anomalies in the specific heat and the susceptibility at temperatures and produces distinct structures in the magnetic excitation spectrum of the clusters that should be possible to detect experimentally.

MA 60.9 Fri 11:30 HSZ 101

The influence of the anti-phase domain structure on the magnetic properties in $Ni_2MnAl_{0.5}Ga_{0.5}$ — •Pascal Neibecker[1,2], Xiao Xu[2], Winfried Petry[1], Ryosuke Kainuma[2], and Michael Leitner[1] — [1]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Lichtenbergstr. 1, 85748 Garching, Germany — [2]Department of Materials Science, Tohoku University, Sendai 980-8579, Japan

The characteristic length scale of the $L2_1$ anti-phase domain (APD) structure has been observed to have a significant influence on the magnetic properties of Heusler alloys [1]. The ideal system to study this phenomenon is $Ni_2MnAl_{0.5}Ga_{0.5}$ where the phase transition temperatures and diffusion kinetics allow to adjust a variety of combinations of degrees of $L2_1$ order and APD sizes. Here, we investigate the effect of the APD length scale on the magnetic properties in $Ni_2MnAl_{0.5}Ga_{0.5}$ via probing the entire accessible parameter space of APD sizes and degrees of $L2_1$ order, starting from B2 order and adjusting different APD scale/ atomic order values via appropriate annealing procedures. We show that both contributions, APD size and degree of order, can clearly be distinguished in magnetization measurements and we use those measurements to follow their respective temporal evolution. In a second step, we simulate APD structures and degrees of $L2_1$ order using Monte Carlo simulations and show via magnetic simulations on the pre-set APD structures that we can reproduce all characteristic features of the experimentally observed magnetization curves.

[1] H. Ishikawa, et al., Acta Materialia 56 (2008), p. 4789-4797

MA 60.10 Fri 11:45 HSZ 101

Spin disorder resistivity of iron at the Earth's core conditions — •Vaclav Drchal[1], Josef Kudrnovsky[1], Ilja Turek[2], David Wagenknecht[2], and Sergii Khmelevskyi[3] — [1]Institute of Physics, Acad. Sci. Czech Rep., Praha, Czech Republic — [2]Department of Condensed Matter Physics, Charles University, Praha, Czech Republic — [3]Center for Computational Materials Science, Vienna University of Technology, Vienna, Austria

Using ab initio calculations and linear response theory, we study the spin-disorder resistivity (SDR) at the Earth's core conditions. The SDR is caused by the scattering of electrons on fluctuating local moments that are stabilized at high temperatures by the magnetic entropy. As an illustration we consider bcc iron. We find a relatively large SDR of order 25 $\mu\Omega$cm but its contribution to the total resisistivity including also phonons is strongly suppressed at high temperatures, leading thus to a large violation of the Matthiessen rule. We also briefly discuss the effects of non-magnetic impurities.