MA 18: Spin Structures and Magnetic Phase Transitions

Time: Wednesday 10:15–13:00 Location: HSZ 401

MA 18.1 Wed 10:15 HSZ 401

New ways of magnetoelastic measurements up to very high magnetic fields — •Mathias Doerr[1], Ariane Haase[2], Erik Kampert[3], Martin Rotter[4], Manuel Zschintzsch[5], Yasuo Narumi[6], and Michael Loewenhaupt[1] — [1]TU Dresden, Institut für Festkörperphysik — [2]FZ Dresden-Rossendorf, Hochfeld-Magnetlabor — [3]St. Radboud Universiteit Nijmegen, High Field Magnet Laboratory — [4]University of Oxford, Clarendon Lab. — [5]TU Dresden, Institut für Strukturphysik — [6]University of Tokyo, ISSP

Scattering methods (x-rays or neutrons) as well as capacitive dilatometry can be used to investigate the magnetostriction (i.e. the change of length or shape) of solids with high accuracy and sensitivity (resolution limit for relative length changes about 10^{-9}). The experimental range of scattering methods, especially, was extended to high magnetic fields of about 30 T in the last years. Therefore, these methods accompany the traditional dilatometry which was developed to work well up to the highest available fields (45 T in constant field magnets and 60 T in pulsed field systems). As examples, thermal expansion (investigated by x-ray diffraction and dilatometry), magnetostriction and magnetization measurements on the rare-earth based compounds Gd_5Ge_3, Tb_5Ge_3 and GdSi are discussed. The magnetoelastic behaviour of both Gd-containing substances shows an unexpected magnetic anisotropy which is caused by exchange striction effects. The complete set of (complementary) experimental methods resulted in a clear knowledge of the phase transitions from which, at least, the magnetic phase diagrams were constructed.

MA 18.2 Wed 10:30 HSZ 401

Spin-phonon coupling in $CuCrS_2$ probed by inelastic neutron scattering — •Julia C.E. Rasch[1,2], Martin Böhm[1], Jürg Schefer[2], Hannu Mutka[1], Galina M. Abramova[3], and Inga G. Vasilyeva[4] — [1]Institut Laue-Langevin, 6 rue Jules Horowitz, BP 156, 38042 Grenoble, Cedex 9, France — [2]Laboratory for Neutron Scattering, ETH Zurich & Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [3]L.V. Kirensky Institute of Physics SB RAS, Krasnoyarsk 660036, Russia — [4]Nikolaev Institute of Inorganic Chemistry SB RAS, Novosibirsk 630090, Russia

The triangular lattice Heisenberg antiferromagnet $CuCrS_2$ ($S = 3/2$) with a quasi two-dimensional layered structure shows a complex three-dimensional magnetic long range order at $T_N = 37$ K. The onset of the magnetic ordering is directly coupled to a lattice distortion from $R3m$ to monoclinic Cm as seen from high resolution neutron powder diffraction data on D1A (ILL). Inelastic neutron powder time-of-flight experiments on IN4 (ILL) revealed below T_N a strong non-dispersive mode localized in Q at about $\hbar\omega = 12$ meV which is characteristic for magnetic clusters. An enhanced scattering intensity at the spin wave-phonon crossing point at $\hbar\omega = 8$ meV is additionally observed. We assume that the monoclinic lattice distortion in $CuCrS_2$ plays a key role in relieving geometrical frustration and is analog to a Spin-Peierls transition in one dimension. Below T_N the nearest neighbor Cr distances change irregular which makes the formation of a valence bond solid [1] favorable and accounts well for the non-dispersive mode at 12 meV. [1] C. Jia and J. H. Han, Phys. Rev. B 73, 172411 (2006)

MA 18.3 Wed 10:45 HSZ 401

Diffuse neutron scattering of interesting phases in Dy2Ti2O7 — •Jonathan Morris[1], Alan Tennant[1,2], Santiago Grigera[3,4], Kirrily Rule[1], and Bastian Klemke[1] — [1]Helmholtz-Zentrum Berlin for Materials and Energy, Glienicker Str. 100, 14109 Berlin, Germany. — [2]Institut fur Festkorperphysik, Technische Universitat Berlin, Hardenbergstr. 36, Berlin 10623, Germany. — [3]St. Andrew's University, St. Andrews, Scotland — [4]Instituto de Física de Líquidos y Sistemas Biológicos, La Plata, Argentina

The prospect of observing emergent magnetic monopoles in spin-ice has recently increased the interest in these systems [1]. Dy2Ti2O7 is a effective spin-1/2 pyrochlore which is a clean model frustrated system where interesting physics may be observed and compared with theory.

Here we present new neutron measurements from E2 at the Helmholtz-Zentrum Berlin which show an agreement with spin-ice correlation functions at 0.7K and 0T, and a complex Q-dependent diffuse scattering at fields below the saturation field along [100]. These are being understood in the context of spin-strings, or spin-random-walks, which are the prerequisite for monopoles. The scattering allows us to follow the development of these strings with field and provides new insight into the Kastelyn physics within this pyrochlore.

[1] "Magnetic monopoles in spin ice" C. Castelnovo, R. Moessner & S. L. Sondhi. Nature 451, 42-45 (3 January 2008)

MA 18.4 Wed 11:00 HSZ 401

Electronic structure and nesting-driven enhancement of the RKKY interaction at the magnetic ordering propagation vector in Gd_2PdSi_3 and Tb_2PdSi_3 — •Dmytro Inosov[1], Daniil Evtushinsky[2], Andreas Koitzsch[2], Volodymyr Zabolotnyy[2], Sergey Borisenko[2], Alexander Kordyuk[2], Matthias Frontzek[3], Michael Loewenhaupt[3], Wolfgang Löser[2], Irina Mazilu[2], Holger Bitterlich[2], Günter Behr[2], Jens-Uwe Hoffmann[4], Rolf Follath[5], and Bernd Büchner[2] — [1]MPI-FKF, Stuttgart, Germany — [2]IFW-Dresden, Germany — [3]TU-Dresden, Germany — [4]HMI, Berlin, Germany — [5]BESSY GmbH, Berlin, Germany.

We present first-time measurements of the Fermi surface and low-energy electronic structure of intermetallic compounds Gd_2PdSi_3 and Tb_2PdSi_3 by means of angle-resolved photoelectron spectroscopy (ARPES). We show that the Fermi surface in both compounds consists of an electron barrel at the Γ point surrounded by spindle-shaped electron pockets originating from the same band, with the band bottom of both features lying at 0.5 eV below the Fermi level. From the experimentally measured band structure, we estimate the momentum-dependent RKKY coupling strength and demonstrate that it is peaked at the $\frac{1}{2}\Gamma K$ wave vector. Comparison with neutron diffraction data from the same crystals shows perfect agreement of this vector with the propagation vector of the low-temperature in-plane magnetic order, thereby demonstrating the decisive role of the Fermi surface geometry in explaining the complex magnetically ordered ground state of ternary rare earth silicides.

MA 18.5 Wed 11:15 HSZ 401

Magnetic properties of $LaO_{1-x}F_xFeAs$ — •Sangeeta Sharma[1,2], John Kay Dewhurst[1,2], Sam Shallcross[3], Christophe Bersier[1,2], Francesco Cricchio[4], Antonio Sanna[2,5], Sandro Massidda[5], E. K. U Gross[2], and Lars Nordstroem[4] — [1]Fritz Haber Institute of the Max Planck Society, Faradayweg 4-6, D-14195 Berlin, Germany — [2]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany — [3]Lehrstuhl für Theoretische Festkörperphysik, Staudstr. 7-B2, 91058 Erlangen, Germany. — [4]Department of Physics, Uppsala University, Box 530, SE-75121 Uppsala, Sweden. — [5]Dipartimento di Fisica, Universita' di Cagliari, Cittadella Universitaria, I-09042 Monserrato(CA), Italy

Using state-of-the-art first-principles calculations we have elucidated the complex magnetic and structural dependence of LaOFeAs upon doping. Our key findings are that (i) doping results in an orthorhombic ground state and (ii) there is a commensurate to incommensurate transition in the magnetic structure between $x = 0.025$ and $x = 0.04$. Our calculations further imply that in this system magnetic order persists up to the onset of superconductivity at the critical doping of $x = 0.05$. Finally, our investigations of the undoped parent compound reveal a small itinerant moment and orthorhombic structure with both moment and distortion angle in excellent agreement with experiments.

MA 18.6 Wed 11:30 HSZ 401

Stripes to bubble transition in Fe/Cu(001) observed using SEMPA in applied magnetic field — •Niculin Saratz, Andreas Lichtenberger, Urs Ramsperger, Thomas Bähler, and Danilo Pescia — Laboratory for Solid State Physics, ETH Zurich, Zurich, Switzerland

Ultrathin Fe films on the Cu(001)-surface have a strong perpendicular magnetic anisotropy. The competition between the dipolar and the exchange interaction results in the formation of magnetic domains. The ground state in zero field consists of parallel stripes of alternating magnetization, whereas in an applied magnetic field the minority domains form bubbles in a homogeneous background of opposite magnetization.

We present the reversible transition from stripe- to bubble domains observed using SEMPA in applied magnetic DC field as a function of both, applied magnetic field and temperature. The associated phase diagram is mapped in T-H-space and an inverse behaviour of the transition line is observed.

MA 18.7 Wed 11:45 HSZ 401

Chirality in Dy/Y Multilayer — •Dieter Lott[1], Sergey V. Grigoriev[2], Yury O. Chetverikov[2], and Andreas Schreyer[1] — [1]GKSS Forchungszentrum, 21502 Geesthacht — [2]Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg 188300, Russia

Chirality plays a crucial role in a wide variety of disciplines from biology to chemistry and physics. However, in the field of magnetism it did not attract a lot of attention until recently, when it was demonstrated for the first time that a single layer of manganese on tungsten orders of a specific chirality. It was interpreted being caused by the Dzyaloshinskii-Moriya (DM) interaction which arises from spin-orbit interactions of electrons due to the breaking of the inversion symmetry at the interface. Here, we present studies using polarized neutron scattering on Dy/Y multilayer structures demonstrating that the magnetic system possess a coherent spin helix with a preferable chirality induced by the magnetic field [1]. The average chirality, being proportional to the difference in the left- and right-handed helix population numbers, is measured as a polarization-dependent asymmetric part of the magnetic neutron scattering. The magnetic field applied in the plane of the sample upon cooling below T_N is able to repopulate the otherwise equal population numbers for the left- and right-handed helixes. The experimental results strongly indicate that chirality observed here for the first time in a multilayer system is a more general phenomenon and may play an important role in future spintronic devices. [1] S.V. Grigoriev, Yu. O. Chetverikov, D. Lott, and A. Schreyer, Phys. Rev. Lett. 100, 197203 (2008).

MA 18.8 Wed 12:00 HSZ 401

Skyrmion textures in uniaxially distorted cubic helimagnets — •U.K. Rössler[1], A.B. Butenko[1,2], A.A. Leonov[1,2], and A.N. Bogdanov[1] — [1]IFW Dresden — [2]Donetsk Inst. for Physics & Technology

In magnetic systems with intrinsic or induced chirality localized and modulated multidimensional structures "Skyrmions" have been predicted to exist as metastable or thermodynamically stable states [1,2]. We show that in cubic helimagnets, as the intermetallic compounds MnSi, FeGe with B20-structure, uniaxial distortions stabilize Skyrmion lattices in a broad range of magnetic fields. Using a phenomenological theory for modulated and localized states in noncentrosymmetric magnetic crystals, the equilibrium parameters of the vortices, helices, and cycloids are determined in dependence on magnetic field and the uniaxial anisotropy induced, e.g., by uniaxial strains. Magnetic phase diagrams hold existence regions for different modulated and homogeneous phases. In particular, multiply modulated Skyrmionic textures are stabilized by an external field similar to the states described earlier for uniaxial crystals [3]. We argue that Skyrmion states could be stabilized in thin layers of cubic helimagnets or ordinary ferromagnets by applying uniaxial stresses. The formation of Skyrmion lattices is determined by the balance of energy gains through double-twist structures in the core and the tails of vortex states. — [1] A.N. Bogdanov, U.K.Rößler, Phys. Rev. Lett. **87**, 037203 (2001). [2] U.K.Rößler, A.N.Bogdanov, C.Pfleiderer, Nature (London) **442**, 797 (2007). [3] A.N. Bogdanov, D.A. Yablonskii, Sov. Phys. JETP **68** 101 (1989).

MA 18.9 Wed 12:15 HSZ 401

Torque anomalies at magnetization plateaux in quantum magnets with Dzyaloshinskii-Moriya interactions — •Salvatore R. Manmana and Frédéric Mila — Institute of Theoretical Physics (CTMC), EPF Lausanne, CH-1015 Lausanne, Schweiz

We investigate the effect of Dzyaloshinskii-Moriya (DM) interactions on torque measurements of quantum magnets with magnetization plateaux in the context of a frustrated spin-1/2 ladder. Using extensive DMRG simulations, we show that the DM contribution to the torque is peaked at the critical fields, and that the total torque is non-monotonous if the DM interaction is large enough compared to the g-tensor anisotropy. More remarkably, if the DM vectors point in a principal direction of the g-tensor, torque measurements close to this direction will show well defined peaks even for small DM interaction, leading to a very sensitive way to detect the critical fields. We propose to test this effect in the two-dimensional plateau system $SrCu_2(BO_3)_2$.

MA 18.10 Wed 12:30 HSZ 401

A generic phase diagram for R_2PdSi$_3$ (R = heavy rare earth)? — •Matthias Frontzek[1], Fei Tang[1], Peter Link[2], Jens-Uwe Hoffmann[3], Jean-Michel Mignot[4], and Michael Loewenhaupt[1] — [1]TU Dresden, Institut für Festkörperphysik, D-01062 Dresden — [2]Forschungsneutronenquelle Heinz-Maier-Leibnitz, Lichtenbergerstr. 1, D-85747 Garching — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Glienickerstr. 100, D-14109 Berlin — [4]Laboratoire Léon Brillouin, CE-Saclay, F-91191 Gif-sur-Yvette

The series R_2PdSi$_3$ (R = heavy rare earth) crystallize in a special variant of the hexagonal AlB_2 structure where the Pd and Si ions order on the B-sites resulting in a crystallographic superstructure. The rare earth ions occupy the Al-sites on a triangular and therefore geometrically frustrated lattice. In zero field the R_2PdSi$_3$ order in a rich variety of antiferromagnetic structures. The diversity reflects the influence of the magneto-crystalline anisotropy based on crystal-electric field effect.

The geometric frustration can be lifted by the application of a magnetic field. Apparently this leads to a more generalized behavior as suggested by ac-susceptibility measurements.

In our contribution we will present and combine results from field dependent ac-susceptibility measurements and magnetic neutron diffraction on single crystalline R_2PdSi$_3$ for selected samples. The existence of a general high-field magnetic structure and a generic behavior for all R_2PdSi$_3$ will be discussed. Its connection to a special variant of the AlB_2 crystallographic structure will be emphasized.

MA 18.11 Wed 12:45 HSZ 401

Single-copy entanglement and entanglement spectrum in spin chains — •Masudul Haque and Andreas Lauchli — Max Planck Institute for Physics of Complex Systems, Dresden, Germany

Features of many-particle physics are often manifested in the entanglement between two parts of a condensed-matter system. The entanglement can be characterized by, e.g., the reduced entropy, the single-copy entanglement, or the complete entanglement spectrum.

I will present results on these quantities in several prominent 1D models of quantum magnetism, namely, the XXZ model, the Majumdar-Ghosh chain, and the spin-1 bilinear-biquadratic chain.