MA 13: Spinstructures and magnetic Phase Transitions

Time: Tuesday 10:15–13:15 Location: H5

MA 13.1 Tue 10:15 H5

First-principles description of phase transitions in transition-metal compounds. — •Leonid Sandratskii — Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

We calculate interatomic exchange parameters in hexagonal MnAs and orthorhombic MnAs. The magnetic transition temperatures are estimated within the mean-field and random-phase approximations. The results of the calculations are used to interpret the unusual sequence of the phase transitions in the system. The limitations of the Heisenberg-Hamiltonian description of the hexagonal MnAs are revealed and interpreted. The importance of the adequate choice of the magnetic degrees of freedom is demonstrated. We obtain strong difference in the properties of hexagonal MnAs and half-metallic Heusler compound NiMnSb.

MA 13.2 Tue 10:30 H5

Nuclear spin ferromagnetic phase transition in an interacting 2D electron gas — •Pascal Simon[1,2] and Daniel Loss[1] — [1]Department of Physics and Astronomie, University of Basel (Switzerland) — [2]LPMMC, university Joseph Fourier & CNRS, Grenoble (France)

Electrons in a two-dimensional semiconducting heterostructure interact with nuclear spins via the hyperfine interaction. Using a a Kondo lattice formulation of the electron-nuclear spin interaction, we show that the nuclear spin system within an interacting two-dimensional electron gas undergoes a ferromagnetic phase transition at finite temperatures. We find that electron-electron interactions and non-Fermi liquid behavior substantially enhance the nuclear spin Curie temperature into the mK range with decreasing electron density.

MA 13.3 Tue 10:45 H5

Magnetic Ordering in Strongly-Correlated Systems from ab initio — •Markus Däne[1], Ian Hughes[2], Arthur Ernst[3], Wolfram Hergert[1], Julie Staunton[2], Axel Svane[4], Julian Poulter[5], Martin Lüders[6], Zdzislawa Szotek[6], and Walter Temmerman[6] — [1]Naturwissenschaftliche Fakultät II, Institut für Physik, Martin Luther Universität Halle-Wittenberg, Friedemann-Bach-Platz 6, 06108 Halle, Germany — [2]Department of Physics, University of Warwick, U.K. — [3]Max Planck Institute of Microstructure Physics, 06120 Halle, Germany — [4]Institute of Physics and Astronomy, University of Aarhus, Denmark — [5]Mahidol University, Bangkok, Thailand — [6]Daresbury Laboratory, Daresbury, Warrington WA4 4AD, U.K.

We use a first-principles theory of finite temperature metallic magnetism to investigate the onset of magnetic order in strongly-correlated systems. Thermally induced spin fluctuations are treated within a mean-field disordered local moment (DLM) picture. The scheme is implemented using the Korringa-Kohn-Rostoker (KKR) method, with a self-interaction corrected local spin-density approximation. This is applied to Ce, Gd and transition metal oxides.

MA 13.4 Tue 11:00 H5

Theory of the helical spin crystal. A candidate for the partially ordered state of MnSi — •Benedikt Binz[1,2] and Ashvin Vishwanath[2] — [1]Institut fuer theoretische Physik, Universitaet zu Koeln — [2]Departement of Physics, University of California, Berkeley

Recent experiments in the "partial order" regime at high pressure in MnSi quite intriguingly suggest diffuse spin correlations and slow dynamics in a pure crystalline metal. As a starting point for a theoretical description of this phase, we are investigating the nature of its dominant spin correlations. Particularly, the observed location of maximal neutron scattering intensity around <110> is difficult to explain in terms of fluctuating helical spin-density waves alone. We therefore investigate helical spin crystals. These are magnetic structures obtained by superimposing distinct spin spirals, via a process reminiscent of crystallization. Based on a phenomenological Landau description, we identify which spin crystal structures may be energetically stabilized and study their properties. One of these states, a bcc spin crystal, is compatible with existing data on MnSi from neutron scattering and magnetic field studies. It also shows new and interesting phenomena, such as symmetry stabilized topological textures, missing higher order Bragg reflections and an octupolar order parameter. Possible routes towards "partial order", which requires the destruction of long-range order by some mechanism, will be briefly discussed.

MA 13.5 Tue 11:15 H5

Discovery of a Cycloidal Spin Spiral in a Two-Dimensional Antiferromagnet — •Matthias Bode[1], Marcus Heide[2], Kirsten von Bergmann[1], Paolo Ferriani[1], Stefan Heinze[1], Gustav Bihlmayer[2], Andre Kubetzka[1], Oswald Pietzsch[1], Stefan Blügel[2], and Roland Wiesendanger[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

Spin structures observed in nanomagnets are commonly explained on the basis of the Heisenberg exchange interaction and the magnetic anisotropy. In a two-dimensional antiferromagnetic metal film with the thickness of a single-atomic Mn layer on W(110) we observe a spin spiral in real space by means of spin-polarized scanning tunneling microscopy at 13 K. First-principles calculations identify the spiral as cycloidal spin order with specific chirality and prove that it is caused by the Dzyaloshinskii-Moriya (DM) interaction arising from the lack of structural inversion symmetry inherent to all surfaces and interfaces. We establish the significance of the DM interaction for magnets in reduced dimensions, whose strength is sufficient to destabilize the so far anticipated collinear magnetic structures. The chirality in nanomagnets can contribute to interesting phenomena in spintronics.

MA 13.6 Tue 11:30 H5

Deconfined spinons and first-order transition in easy-plane quantum antiferromagnets — •Flavio Nogueira[1], Steiner Kragset[2], and Asle Sudbo[3] — [1]Institut für Theoretische Physik, Freie Universität Berlin — [2]Department of Physics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway — [3]Department of Physics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway

We report recent Monte Carlo and renormalization group results for quantum antiferromagnets in the deep easy-plane limit [1]. By performing large scale Monte Carlo simulations, we are able to show that the spinons are deconfined at the phase transition point. This is in agreement with the recently proposed scenario in which a destructive interference mechanism between instantons and the Berry phase deconfine the spinons at the phase transition. However, we show that the phase transition is first-order, in contrast with the second-order phase transition predicted by the deconfined quantum criticality scenario. Our numerical results are confirmed by a renormalization group analysis of the system at the critical point.

[1] S. Kragset, E. Smørgrav, J. Hove, F. S. Nogueira, and A. Sudbø, Phys. Rev. Lett. **97**, 247201 (2006)

MA 13.7 Tue 11:45 H5

Low temperature formalism for glassy order — •Manuel Joachim Schmidt and Reinhold Oppermann — Institut für Theoretische Physik und Astrophysik, Am Hubland, 97074 Würzburg

While the low temperature limit usually simplifies the description of physical systems in a very obvious way, this limit can remain complicated in case of disordered systems like spin- or structural glasses. The reason for this is the appearance of replica-symmetry-breaking (RSB), which complicates the analysis even of the simplest models. The mean-field theory of systems which exhibit RSB needs an infinite number of order parameters which are conveniently described as an order function. For temperatures well below the spin-glass transition temperature, only numerical solutions are available. The approach to T=0, however, is plagued by singularities within the traditional formalism. The proper T=0 limit of the order function and its implications is the objective of our work.

We have developed a novel formalism, free of singularities, which allows for the treatment of RSB in spin glasses and other random systems at low temperatures and directly at T=0. Physical observables like the ground state energy or susceptibilities have been obtained with unprecedented accuracy.

MA 13.8 Tue 12:00 H5

Uniform and Staggered Magnetizations Induced by Dzyaloshinskii-Moriya Interactions in Isolated and Coupled Spin 1/2 Dimers in a Magnetic Field — S. Miyahara[1], J.-B.

Fouet[2], •S. Manmana[3,4,5], R. Noack[5], H. Mayaffre[6], I. Sheikin[7], C. Berthier[6,7], and F. Mila[3] — [1]Dep. of Physics, Aoyama Gakuin University, Sagamihara, Kanagawa 229-8558, Japan — [2]IRRMA, PPH-Ecublens, CH-1015 Lausanne, Switzerland — [3]Inst. of Theor. Phys., EPFL, CH-1015 Lausanne, Switzerland — [4]ITP III, Univ. Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart, Germany — [5]Fachb. Physik, Philipps-Univ., D-35032 Marburg, Germany — [6]Lab. de Spectr. Phys., Univ. J. Fourier & UMR5588 CNRS, BP 87, 38402, Saint Martin d'Hères, France — [7]GHMFL., CNRS, BP 166, F-38042 Grenoble Cedex 09, France

We investigate the interplay of Dzyaloshinskii-Moriya (DM) interactions and an external field in spin 1/2 dimers. For isolated dimers and at low field, we find in the limit where the D vector of the DM interaction is parallel to the external field a uniform magnetization *perpendicular* to the field. For larger fields, we find the staggered magnetization of an isolated dimer to have a maximum close to one-half the polarization. We investigate the effect of inter-dimer coupling in the context of ladders with Density Matrix Renormalization Group (DMRG) calculations and show that, as long as the parameters allow the staggered magnetization to be finite, the simple picture for isolated dimers is valid for weakly coupled dimers with minor modifications. The results are compared with torque measurements on $Cu_2(C_5H_{12}N_2)_2Cl_4$.

MA 13.9 Tue 12:15 H5

New features in the phase diagram of $TbMnO_3$ — •D. Meier[1,2], N. Aliouane[3], D. Argyriou[3], J. Mydosh[1], and T. Lorenz[1] — [1]II. Physikalisches Institut, University of Cologne, 50937 Cologne, Germany — [2]HISKP, University of Bonn, 53115 Bonn, Germany — [3]Hahn-Meitner-Institut, 14109 Berlin, Germany

We report new features in the phase diagram of the magnetoelectric (ME) multiferroic $TbMnO_3$, derived by thermal expansion and magnetostriction measurements. Below $T_N = 41$ K the Mn spins develop an incommensurate sinusoidal antiferromagnetic ICAFM alignment. Below $T_{\rm FE} = 28$ K, the ICAFM order changes into a helix and a spontaneous electric polarization $P||c$ appears. Sufficiently high magnetic fields $H||a$ or $H||b$ induce a polarization flop ($P||c \rightarrow P||a$), accompanied by a commensurate antiferromagnetic (CAFM) order of the Mn spins. Strongly anisotropic thermal expansion was measured along the crystal axes a, b and c (Pbnm). We observe pronounced anomalies when the various phase boundaries are crossed as a function of T or H, reflecting large uniaxial pressure dependencies of the transition temperatures or fields. Thus, our data allow a detailed investigation of the (H,T) phase diagram. Opposite to previous publications, we find that even in high fields there are no direct transitions from the sinusoidal ICAFM- to the CAFM-phase. For $H||a$, the hysteretic phase boundary between the phases with $P||c$ and $P||a$ was detected in detail for the first time. Furthermore, complex phase boundaries reflecting changes in the Tb ordering for $H||i$ ($i = a, b, c$) were determined.

This work was supported by the DFG through SFB 608.

MA 13.10 Tue 12:30 H5

Magnetic phase diagram of Tb_2PdSi_3 studied by neutron diffraction — •Matthias Frontzek[1], Andreas Kreyssig[1], Mathias Doerr[1], Astrid Schneidewind[1,2], Jens-Uwe Hoffmann[3], and Michael Loewenhaupt[1] — [1]TU Dresden, Institut für Festköperphysik, D-01062 Dresden — [2]Forschungsneutronenquelle Heinz-Maier-Leibnitz, Lichtenbergerstr. 1, D-85747 Garching — [3]Hahn-Meitner-Institut, Glienickerstr. 100, D-14109 Berlin

Tb_2PdSi_3 crystallises in an AlB_2 derived hexagonal structure (space group $P6/mmm$) yielding a latent geometric frustration for the magnetic Tb^{3+} ions. The anisotropy of the crystal electric field leads to a magnetic easy basal plane with six possible moment directions. The RKKY interaction gives rise to an antiferromagnetic transition at $T_{\rm N} = 23$ K. To clarify the microscopic nature of the rich magnetic phase diagram we performed neutron scattering experiments in external magnetic fields up to $\mu_0 H = 6.5$ T along the (100) direction.

In zero field we observe an antiferromagnetic long-range ordered (LR) structure with a magnetic unit cell doubled in the basal plane with respect to the chemical unit cell and a (0 0 1/16) propagation along the hexagonal axis. Below 8 K an additional antiferromagnetic short range ordered (SR) structure with a wave vector (0.16 0.16 0.06) appears. The LR propagation changes through two intermediate phases to (0 0 1/4) in the field range 0.1 - 3.0 T. The SR structure seems decoupled from the LR structure and becomes itself long-range ordered around 1.5 T with a propagation (0.13 0.13 0.1) which is further modified to (1/6 1/6 1/4) at fields above 3 T.

MA 13.11 Tue 12:45 H5

Neutron Scattering on the Spin-Orbit Liquid State of $FeSc_2S_4$ — •Michael Mücksch[1,2], Alexander Krimmel[1], Vladimir Tsurkan[1,3], Denis Sheptyakov[4], Michael Marek Koza[2], Amir Murani[2], Hannu Mutka[2], Siegfried Horn[1], and Alois Loidl[1] — [1]Institute of Physics, University of Augsburg, D-86159 Augsburg, Germany — [2]Institute Laue Langevin, F-38042 Grenoble, France — [3]Institute of Applied Physics, Academy of Sciences of Moldova, MD-2028 Chisinau, R. Moldova — [4]Laboratory for Neutron Scattering, ETH Zürich & PSI, CH-5232 Villigen PSI, Switzerland

The developement of the spin-orbital liquid ground state in the normal cubic spinel compound $FeSc_2S_4$[1] based on the electronic degenerate magnetic Fe^{2+} ($3d^6$) ions is studied by extensive neutron scattering studies. The dynamic structure factor $S(Q,\omega)$ as obtained by neutron time-of-flight measurements exhibits at 300 K a paramagnetic quasielastic contribution, which evolves below about 120 K into a broad excitation band centered around 2 meV with a softening at particular Q - positions. This indicates a dynamic Jahn-Teller effect including spin-orbit coupling and magnetic exchange [2]. Implications on the neutron derived phonon spectra will be discussed. The magnetic excitation spectra, and in particular the gap value, are not affected by either cooling down to 200 mK or applying an external field of 2.5 T. The resolution limited elastic scattering shows a remaining paramagnetic contribution, but no changes on cooling down to 200mK, thus excluding spin glass freezing. This demonstrates the dynamic character of the ground state in $FeSc_2S_4$.[1] V. Fritsch et al., Phys. Rev. Lett. **92** (2004) 116401.[2] A. Krimmel et al., Phys. Rev. Lett. **94** (2005)237402.

MA 13.12 Tue 13:00 H5

Magnetostriction in high pulsed magnetic fields — •Wolfram Lorenz[1], Nadejda Kozlova[2], Jos Perenboom[3], Mathias Doerr[1], and Michael Loewenhaupt[1] — [1]TU Dresden, D-01062 Dresden — [2]IFW Dresden, Helmholtzstraße 20, D-01069 Dresden — [3]Radboud University Nijmegen, 6525 ED Nijmegen

Measurements of the magnetostriction complement very well the set of experimental methods in high pulsed magnetic fields. It allows not only to examine the interaction of magnetic moments with each other but also with the lattice system. Nowadays pulsed magnets with up to 100 T are under development, for which magnetostriction is a promising experimental method.

To measure magnetostriction up to the highest available fields a special capacitive dilatometer has been developed. It yields a high resolution of magnetostrictive effects ($\sim 10^{-5}$ in Δl/l) in magnetic fields up to 50 T and at temperatures down to 2 K. Its special design reduces the influence of eddy currents and mechanical vibrations.

First experiments with this setup have been made on the rare earth compounds GdSi and $SmCu_2$ that show transitions at 20 T and 30 T, respectively. Our data are in excellent agreement with measurements done in static fields (Bitter-magnet). We could verify the spin-flop character of the transition of GdSi. For $SmCu_2$ the magnetic phase diagram has been constructed, which shows clear indication for a temperature dependent compensation of its spin and orbital momentum.

In this talk the measuring setup and first experimental results will be presented.