MA 5: Spin Structures and Magnetic Phase Transitions

Time: Monday 9:30–12:30 Location: H 0112

MA 5.1 Mon 9:30 H 0112

Structure and Phase Transitions of the Spiral Antiferromagnet $Ba_2CuGe_2O_7$ in Canted Magnetic Fields — •Sebastian Mühlbauer[1], Severian Gvasaliya[1], Eric Ressouche[2], Ekaterina Pomjakushina[3], and Andrey Zheludev[1] — [1]Neutron Scattering and Magnetism Group, Laboratory for Solid State Physics, ETH Zürich, Switzerland — [2]INAC/SPSMS-MDN, CEA/Grenoble, 38054 Grenoble Cedex 9, France — [3]Laboratory for Developments and Methods (LDM), Paul Scherrer Institute, Switzerland

Neutron diffraction in combination with measurements of the susceptibility and specific heat have been used to systematically study the different magnetic structures of the non-centrosymmetric tetragonal antiferromagnet (AF) $Ba_2CuGe_2O_7$, that evolve for different orientation of the magnetic field. For magnetic field close to the tetragonal c-axis, a phase transition from the soliton lattice to a recently reported incommensurate double-k AF-cone phase [1] is confirmed. In contrast, for large angles enclosed by the magnetic field and the c-axis, a smooth crossover to a complexly distorted non-sinusoidal structure is observed by neutron diffraction. Measurements of susceptibility and specific heat furthermore indicate the existence of a incommensurate/commensurate transition for magnetic fields ≈ 9 T applied in the basal (a, b)-plane. The results show a virtually identical behavior for the magnetic field confined in both a (1,0,0) and (1,1,0) crystallographic plane and agree with a non-planar, asymmetrically distorted cycloidal magnetic structure.

[1] S. Mühlbauer et al., Phys. Rev. B **84**, 180406 (2011)

MA 5.2 Mon 9:45 H 0112

Frustrated Ising spins simulated by spinless bosons in a tilted lattice: from disordered quantum liquids to antiferromagnetic order — •Susanne Pielawa[1,2], Erez Berg[1], and Subir Sachdev[1] — [1]Department of Physics, Harvard University, Cambridge MA 02138, USA — [2]Department of Condensed Matter Physics, The Weizmann Institute of Science, Rehovot, 76100 Israel

Recently a quantum antiferromagnetic spin chain has been simulated experimentally using spinless bosons in a tilted optical lattice [Nature 472, 307 (2011)]. Extending this idea to two dimensions, we theoretically analyze a setup of spinless bosons in a decorated square lattice tilted along the diagonal. This system simulates a quantum Ising model with antiferromagnetic interactions on a non-bipartite lattice. The lattice geometry thus prevents the system from ordering, even in the limit where the effective antiferromagnetic coupling is strong compared to the magnetic fields. This frustration can be reduced by changing the tilt angle slightly away from the diagonal, and the system undergoes a transition to an antiferromagnetically ordered state. We find that the disordered liquid-like state is continuously connected a the paramagnetic state. Using quantum Monte Carlo simulations and exact diagonalization we find that for realistic system sizes the antiferromagnetic order will appear to be one-dimensional; however in the thermodynamic limit the order is two-dimensional.

MA 5.3 Mon 10:00 H 0112

quantum phases in the S=1/2 heisenberg model on the cairo pentagonal lattice — •Ioannis Rousochatzakis[1,2], Andreas Laeuchli[1], and Roderich Moessner[1] — [1]Max Planck Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [2]Institute for Theoretical Solid State Physics, IFW Dresden, 01171 Dresden, Germany

We present an extensive analytical and numerical exact diagonalization study of the spin S=1/2 antiferromagnetic Heisenberg model on the Cairo pentagonal lattice. This is the dual of the Shastry-Sutherland lattice and has been discussed as a possible new candidate for having a spin liquid ground state. More recently a close realization of this model has appeared in the S=5/2 compound $Bi_2Fe_4O_9$. Here we use a model with two different exchange couplings allowed by the symmetry of the lattice, and investigate the nature of the ground state as a function of their ratio x. After establishing the classical phase diagram we switch on quantum mechanics in a gradual way that highlights the different role of quantum fluctuations on the two inequivalent sites of the lattice. The most important findings include: (i) a surprising interplay between a collinear and a four-sublattice orthogonal phase due to an underlying order-by-disorder mechanism which is active at small x, and (ii) a non-magnetic and possibly spin-nematic phase with d-wave symmetry at intermediate x. The latter is driven by an effective 4-spin exchange term that first appears in fourth order perturbation theory in x.

MA 5.4 Mon 10:15 H 0112

Electrons confinement effect on orbital moment and magnetocrystalline anisotropy of Fe/Ag(001) — •Maciej Dabrowski[1], Uwe Bauer[1], Marek Przybylski[1], Takeshi Nakagawa[2], Yasumasa Takagi[2], Toshihiko Yokoyama[2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — [2]Department of Materials Molecular Structure, Institute for Molecular Science, Myodaiji-cho, Okazaki, 444-8585, Japan

In a thin film, electron motion can be confined by potential barriers at the interfaces, resulting in the formation of quantum well states (QWS). In particular, in ferromagnetic thin films, the quantization of d-bands can lead to oscillations of the magnetocrystalline anisotropy as a function of film thickness [1,2].

Using x-ray magnetic circular dichroism (XMCD) and magneto-optic Kerr effect (MOKE), we demonstrate a relation between electrons confinement, magnetocrystalline anisotropy and orbital moment in Fe films grown on vicinal surfaces of Ag(001). We show that a spin reorientation transition from in-plane to out-of-plane simultaneously occurs with in-plane magnetization rotation, which is determined by the QWS contribution to the magnetocrystalline anisotropy.

[1] J. Li, M. Przybylski, F. Yildiz, X. D. Ma, and Y. Z. Wu, Phys. Rev. Lett. 102, 207206 (2009)

[2] U. Bauer M. Dabrowski, M. Przybylski, and J. Kirschner, Phys. Rev. B 84, 144433 (2011)

MA 5.5 Mon 10:30 H 0112

Modulated states in chiral helimagnets with easy-plane anisotropy — •Anna B. Butenko[1], Alexei N. Bogdanov[1], Ulrich K. Rössler[1], Eric A. Karhu[2], Michael D. Robertson[3], and Theodore L. Monchesky[2] — [1]IFW Dresden, Germany — [2]Dalhousie University, Halifax NS, Canada — [3]Acadia University, Wolfville NS, Canada

A surface-induced uniaxial anisotropy of easy-axis type can stabilize hexagonal Skyrmion lattices in nanostructures of isotropic or cubic chiral magnets. In these modulated states with field applied along the anisotropy axis, the Skyrmions run along the axis. This effect explains experimental observations of Skyrmion lattices in thin layers of cubic helimagnets (Fe,Co)Si and FeGe. We find that another type of Skyrmion lattice can be stabilized in uniaxial magnets of easy-plane type, when the field is applied perpendicularly to the axis. Detailed results from calculations of the magnetic phase diagram for the model of an isotropic chiral helimagnet with induced easy-plane uniaxial anisotropy are presented. Depending on the strength of the anisotropy, different sequences of magnetization processes can occur with phase transitions between helicoidal transverse modulations, elliptically distorted conical helices and Skyrmion lattices. The theoretical results are shown to be relevant for epitaxial MnSi (111) thin films with strain-induced easy-plane anisotropy. Ab initio calculations confirm the easy-plane character of the induced magnetic anisotropy in rhombohedrally distorted MnSi (111) with isotropic and tensile strains in the basal plane.

MA 5.6 Mon 10:45 H 0112

High-field magnetism and magneto-acoustics in UCo_2Si_2 — •S. Yasin[1], A.V. Andreev[2], Y. Skourski[1], S. Zherlitsyn[1], and J. Wosnitza[1] — [1]Dresden High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany — [2]Institute of Physics ASCR, Na Slovance 2, 18221 Prague 8, The Czech Republic

We report results of magnetization and magneto-acoustic studies on a UCo_2Si_2 single crystal in high magnetic fields. This compound orders antiferromagnetically at the Néel temperature $T_N = 83$ K and shows at low temperatures a first-order metamagnetic transition (MT) at 45 T with very small hysteresis ($\mu_0 \Delta H_{cr} = 0.16$ T) to a ferrimagnetic state seen as a sharp jump in the magnetization when the magnetic field is applied along the c direction. The magnetization curve measured along the a axis shows no transition and is linear up to 60 T. The acoustic properties exhibit drastic anomalies in the vicinity of both magnetic phase transitions; the spontaneous and the field-induced one. At T_N, a pronounced change in the sound velocity Δv/v accompanied with a peak in the attenuation $\Delta\alpha$ has been observed. Whereas $\Delta\alpha$ only shows a very sharp peak at the MT, Δv/v displays a more complicated behavior; it has a non-monotonous temperature evolution with maximum effects at 30 K, which can be due to the transition changing from first to second order. Our results enabled us to map the phase diagram of UCo_2Si_2 in fields applied along the c axis. We discuss our observations in relation to the magnetism on the U site and the magneto-elastic interaction in this material. *Part of this work was supported by EuroMagNET under the EU contract No. 228043.

15 min. break

MA 5.7 Mon 11:15 H 0112

Magnetic phase diagram of $Eu_{1-x}Gd_xS$ — •Roman Rausch[1], Wolfgang Nolting[2], and Michael Potthoff[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg — [2]Festkörpertheorie, Institut für Physik, Humboldt-Universität Berlin

We present self-consistent RKKY calculations of the critical temperatures of the antiferromagnetic phases within the pure Kondo-lattice model (sc and fcc lattices). Extending the results to chemical and magnetic disorder, we are able to calculate the phases of the concentrated spin system $Eu_{1-x}Gd_xS$ which agree well with the experiment. This substance also shows a spin-glass phase whose origin is briefly discussed from a proposed microscopic principle.

MA 5.8 Mon 11:30 H 0112

Phase diagram of hard-core bosons on clean and disordered 2-leg ladders: Mott insulator, Luttinger liquid, Bose glass — •Francois Crepin[1], Nicolas Laflorencie[2], Pascal Simon[3], and Guillaume Roux[4] — [1]Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany — [2]LPT, Université de Toulouse, UPS (IRSAMC), Toulouse, France — [3]LPS, Université Paris-Sud, UMR-8502 CNRS, F-91405 Orsay, France — [4]LPTMS, Université Paris-Sud, UMR-8626 CNRS, F-91405 Orsay, France

While one-dimensional free fermions and hard-core bosons are often considered to be equivalent, coupling only two chains enables particle exchange and leads to totally different physics for free fermions and HC bosons. Combining analytical (strong coupling, field theory) and numerical (quantum Monte Carlo, DMRG) approaches, we study the apparently simple but nontrivial model of HC bosons in a two-leg ladder geometry. At half-filling, while a band insulator appears for fermions at large interchain hopping $t_\perp > 2t$ only, a Mott gap opens up for bosons as soon as $t_\perp \neq 0$ through a Kosterlitz-Thouless transition. Away from half-filling, a gapless Luttinger liquid mode emerges in the symmetric sector with a nontrivial filling-dependent Luttinger parameter $1/2 \leq K_s \leq 1$. We discuss consequences for experiments on spin ladders in a magnetic field and cold atoms, as well as disorder effects. Indeed, a quantum phase transition at finite disorder strength is expected, between a 1D superfluid and an insulating Bose glass phase. F. Crépin *et al.*, Phys. Rev. B, **84**, 054517 (2011)

MA 5.9 Mon 11:45 H 0112

Z2 vortices in 2D triangular Cr-spin lattices — •Mamoun Hemmida, Hans-Albrecht Krug von Nidda, and Alois Loidl — Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany

Using Electron-Spin-Resonance spectroscopy, we discovered a universal spin-spin relaxation law in two-dimensional frustrated triangular lattice antiferromagnets. The rock salt compounds HCrO2, LiCrO2, and NaCrO2 as well as the delafossite compounds CuCrO2, AgCrO2, and PdCrO2 show a characteristic temperature dependence of the resonance linewidth, indicating relaxation via a certain kind of magnetic vortices, the so-called Z2 vortices. These vortices have been suggested originally by Kawamura and Miyashita (KM) [1]. Their work is an extension to the well-known Berezinskii-Kosterlitz-Thouless (BKT) scenario [2]. Indeed, as it is currently well established [4], the KM scenario seems to be an analogue to the earlier extension of BKT scenario, i.e. Kosterlitz-Thouless-Halperin-Nelson-Young (KTHNY) model [3], which describes successfully the melting process in a two-dimensional liquid crystal. In the frame of this presentation other recent experimental results obtained by Nuclear-Magnetic-Resonance (NMR) and Muon-Spin-Rotation (μSR) as well as current theoretical studies will be included to promote the interpretation of the up-to-date ESR results. References: [1] H. Kawamura, and S. Miyashita, J. Phys. Soc. Jpn. 53, 4138 (1984). [2] J. M. Kosterlitz and D. J. Thouless, J. Phys. C 6, 1181 (1973). [3] B. I. Halperin and D. R. Nelson, PRL. 41, 121 (1978). [4] M. Hemmida, et al., J. Phys. Soc. Jpn. 80, 053707(2011).

MA 5.10 Mon 12:00 H 0112

Atomic Scale Magnetic Dissipation from Spin-Dependent Adhesion Hysteresis — •Elena Y. Vedmedenko, Q. Zhu, U. Kaiser, A. Schwarz, and R. Wiesendanger — Institute of Applied Physics, University of Hamburg Jungiusstr. 11, 20355 Hamburg, Germany

The experimental observation of atomic scale magnetic dissipation by magnetic exchange force microscopy [1] on NiO(001) with an Fe-coated tip is reported. The origin of the dissipation signal has been investigated using Monte-Carlo energy minimization techniques and compared with experimental results. The calculations predict that the Caldeira-Leggett-type dissipation proposed previously [2] is a special case of the general phenomenon of adhesive hysteresis. According to our calculations the adhesion hysteresis is distance as well as spin dependent and should be measurable not only above magnetic Ni but also on paramagnetic O atoms. The energy released during binding or the unbinding process may then be dissipated via spin flips or phonons. Considering the simplicity of our theoretical model, the calculated energy dissipation agrees surprisingly well with the measured energy dissipation.

[1] U. Kaiser, A. Schwarz, R. Wiesendanger, Nature, 446, (522), (2007)
[2] F. Pellegrini, G. E. Santoro, E. Tosatti, Phys. Rev. Lett. 105, (146103), (2010)

MA 5.11 Mon 12:15 H 0112

Neutron reflectometry of Fe_3O_4 thin films through the Verwey Transition — •Mehrdad Baghaie Yazdi[1], Marton Major[1], Andrew Wilders[2], Wolfgang Donner[1], and Lambert Alff[1] — [1]Technische Universität Darmstadt, Darmstadt, Deutschland — [2]ILL, Grenoble, Frankreich

The Verwey transition in magnetite, Fe_3O_4, is still a not-understood phenomenon. At the Verwey point - which is a first-order-transition - a series of physical property changes, such as conductivity, crystal structure, and magnetization. We have grown epitaxial thin films on (100) MgO substrates by rf-magnetron sputtering. These films show extremely large changes in the magnetization at the Verwey transition making them ideal study objects. We have applied neutron reflectometry through the Verwey transition to understand the nature of the changes in magnetization. One important question addressed is the possibility of magnetic axes switching as origin of the steep drop in magnetization.