TT 8: Correlated Electrons: Spin Systems and Itinerant Magnets 1

Time: Monday 14:00–18:00 Location: H 0104

TT 8.1 Mon 14:00 H 0104

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TT 8.2 Mon 14:15 H 0104

Magnetic phase diagram of MnSi revisited — •Florian Jonietz[1], Sebastian Mühlbauer[1,2], Christian Pfleiderer[1], Achim Rosch[3], Rembert Duine[4], Andreas Neubauer[1], Stefan Legl[1], Robert Georgii[1,2], and Peter Böni[1] — [1]Physik-Department E21, Technische Universität München, D-85748 Garching, Germany — [2]Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II), Technische Universität München, D-85748 Garching, Germany — [3]Institute of Theoretical Physics, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln, Germany — [4]Institute for Theoretical Physics, Department of Physics and Astronomy, Utrecht University, 3584 CE Utrecht, The Netherlands

The lack of inversion symmetry in the crystal structure of the itinerant-electron magnet MnSi results in weak Dzyaloshinsky-Moriya interactions, that stabilize a long-wavelength spin spiral ($\lambda \sim 190$ Å) in the magnetically ordered state. Motivated by recent neutron scattering studies of the magnetic phase diagram at high pressures we have revisited the magnetic phase diagram at ambient pressure. We report the results of extensive measurements of the AC susceptibility and small angle neutron scattering of the magnetic order of MnSi as function of temperature, magnetic field and electric current. In our study we focus in particular on the stability of the A-phase, a small phase pocket, where the helical order spontaneously aligns perpendicular to the direction of an applied magnetic field.

TT 8.3 Mon 14:30 H 0104

Spherical neutron polarimetry of the magnetic structure in MnSi — •Marc Janoschek[1], Florian Bernlochner[1], Sebastian Mühlbauer[1,2], Robert Georgii[1,2], Christian Pfleiderer[1], and Peter Böni[1] — [1]Physik-Department E21, Technische Universität München, D-85748 Garching, Germany — [2]Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II), Technische Universität München, D-85748 Garching, Germany

Dzyaloshinsky-Moriya interactions stabilize a long-wavelength spin spiral ($\lambda \sim 190$ Å) in the magnetically ordered state of B20 compound MnSi. Recent theoretical studies [1] suggest that the DM interactions may not only stabilize straight-forward helical order, but also additional complex magnetic textures, when the amplitude of the local magnetization is soft and supports strong longitudinal fluctuations, e.g. near critical phase transitions. Polarized neutron scattering provides a unique microscopic tool for the determination of magnetic structures. We have explored the question of the magnetic order and related magnetic textures in MnSi by means of spherical neutron polarimetry using the module MuPAD. We have focussed in particular on the nature of the magnetic state in the vicinity of the helical to paramagnetic phase boundary, where bulk properties reveal weak evidence for additional phase transitions. [1] U. K. Rößler, A. N. Bogdanov, C. Pfleiderer *Nature* **442**, 797 (2006).

TT 8.4 Mon 14:45 H 0104

Gauge theory description and possible spin charge separation in itinerant chiral magnets — •Benedikt Binz and Achim Rosch — Universitaet zu Koeln

By applying pressure to the itinerant chiral magnet MnSi, a state with non-Fermi liquid electrical transport and unusual partially ordered magnetism has been observed. These experiments quite intriguingly suggest diffuse spin correlations and slow dynamics in a pure crystalline metal.

As a possible route towards a theory of the partially ordered state, we show that electrons interacting with a fluctuating magnetic background have a natural gauge theory description. We introduce new variables, where spin and charge of the conduction electrons appear separated. In this language, the helically ordered phase appears as a Anderson-Higgs phase where the gauge field is gapped and the low-energy helimagnon spectrum is obtained. It is currently not known whether this gauge theory also has (deconfined) disordered phases, which could account for the unusual behavior of MnSi under pressure.

TT 8.5 Mon 15:00 H 0104

Search for helimagnon excitations in MnSi: an inelastic neutron scattering study — •Florian Bernlochner[1], Marc Janoschek[1], Peter Böni[1], Sarah Dunsiger[1], Bertrand Roessli[2], Peter Link[3], Christian Pfleiderer[1], and Achim Rosch[4] — [1]Physik-Department E21, Technische Universität München, D-85748 Garching, Germany — [2]Laboratory for Neutron Scattering, ETH Zürich & Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland — [3]Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II), Technische Universität München, D-85748 Garching, Germany — [4]Institute of Theoretical Physics, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln, Germany

The lack of inversion symmetry in the crystal structure of the itinerant-electron magnet MnSi results in weak Dzyaloshinsky-Moriya interactions, that stabilize a long-wavelength spin spiral ($\lambda \sim 190$ Å) in the magnetically ordered state. Recent theoretical studies [1-3] predict a rich, novel spectrum of the Goldstone modes, also referred to as helimagnons, for sufficiently small wave vectors near the helical ordering wave vector. We present the results of extensive inelastic neutron scattering studies, in which we explore the nature of the low lying excitations in MnSi in the helically ordered state.

[1] D. Belitz, T. R. Kirkpatrick *Phys. Rev. B* **72**, 180402(R) (2005)
[2] D. Belitz, T. R. Kirkpatrick and A. Rosch *Phys. Rev. B* **73**, 054431 (2006)
[3] S. V. Maleyev, *Phys. Rev. B* **73**, 174402 (2006).

15 min. break

TT 8.6 Mon 15:30 H 0104

Evolution of the 'Orbital Peierls State' with doping — •C. Ulrich[1], G. Khaliullin[1], M. Reehuis[1,2], K. Schmalzl[3], A. Ivanov[3], K. Hradil[4], J. Fujioka[5], Y. Tokura[5], and B. Keimer[1] — [1]MPI-FKF, Stuttgart — [2]HMI, Berlin — [3]ILL Grenoble, France — [4]FRM II, Munich — [5]University of Tokyo, Japan

Orbital degrees of freedom play an important role in the physics of strongly correlated electron systems. Our extensive investigation of insulating vanadates by neutron scattering has led to the discovery of an unusual magnetic ground state due to the interplay between spin and orbital degrees of freedom. YVO_3 exhibits two magnetic phases, a C-type phase between 116 K and 77 K and a G-type phase below 77 K. While the magnetic properties of the G-type phase are in accordance with standard theoretical descriptions, the C-type phase shows highly unusual static and dynamic spin correlations. Based on the idea of orbital fluctuations we were able to identify this phase as a theoretically predicted but hitherto unobserved 'orbital Peierls state' [1].
Our latest neutron scattering experiments show that the C-type phase in $Y_{1-x}Ca_xVO_3$, i.e., the 'orbital Peierls phase', is stabilized upon doping, while the orbitally ordered G-type phase is quite unstable and disappears at x = 2 %. Furthermore, with doping this phase also exhibits a highly unusual spin wave dispersion. This leads us to the conclusion, that the 'orbital Peierls state' becomes more robust with Ca-doping, whereas the formerly well defined G-type phase exhibits a more complex behavior, probably as a consequence of an increase in orbital fluctuations.

[1] C. Ulrich et al., PRL **91**, 257202 (2003).

TT 8.7 Mon 15:45 H 0104

Spin and Singlet Dynamics of the S=1/2 Kagome Antiferromagnet — •Andreas M. Laeuchli[1] and Claire Lhuillier[2] — [1]IRRMA, EPF Lausanne, Switzerland — [2]LPTMC, Universite P. & M. Curie, Paris, France

The kagome Heisenberg antiferromagnet with spin 1/2 has been the topic of many theoretical investigations. Most of these focused on groundstate properties or aiming at an explanation of the anomalous high density of singlet excitations. In this contribution we report on recent exact diagonalization studies concentrating on dynamical correlation functions. First the full dynamical spin structure factor S(q,omega) on 36 sites has been obtained. Then we also discuss the time dependent spin autocorrelation function as well as dynamical dimer-dimer correlation functions. All these results combined together point towards a highly fluctuating system, both in the singlet and the triplet channel. We conclude by a comparison with recent inelastic neutron scattering measurements on the Herbertsmithite compound.

TT 8.8 Mon 16:00 H 0104

High field magnetic resonance study of the spin antiferromagnet $GdNi_2B_2C$ (exchanged with TT 30.4) — •Ferenc Murányi[1], Uwe Schaufuss[1], Mathias Dörr[2], Martin Rotter[3], Vladislav Kataev[1], and Bernd Büchner[1] — [1]IFW Dresden, Institute for Solid State Research, D-01171 Dresden, PO BOX 270116, Germany — [2]Institut for Physics of Solids, Technical University Dresden, D-01062 Dresden, Germany — [3]Institute for Physical Chemistry, University of Vienna, A-1090 Vienna, Währingerstr. 42, Austria

The Antiferromagnetic Resonance (AFMR) was measured on a thick slab of single crystal $GdNi_2B_2C$ in the antiferromagnetic state. In the paramagnetic state Electron Spin Resonance (ESR) study was done. The magnetic properties of the material were studied applying the external magnetic field parallel and perpendicular to the easy plane. The measured data revealed the anisotropy of the Korringa relaxation rate in the paramagnetic state indicating anisotropic interaction between the localized 4f moments and conduction electrons. In the antiferromagnetic state we observed a large out-of-plane anisotropy gap of $\sim$76 GHz which is higher than expected from the dipole-dipole interaction. Surprisingly, we also observed an in-plane gap with the same order of magnitude. In addition we found indications that the external magnetic field induces symmetry-breaking distortions in this material. The work was supported by DFG through SFB 463.

TT 8.9 Mon 16:15 H 0104

Impurity induced spin textures in quantum antiferromagnets — •Julian Engel and Stefan Wessel — Institute for Theoretical Physics III, Stuttgart University, Germany

We present results from quantum Monte Carlo studies on the effects of a magnetic impurity on the order parameter distribution in a two-dimensional host antiferromagnet. We find that for a weak coupling to the impurity spin, the staggered magnetization is enhanced throughout the lattice, whereas increasing the coupling between the host and the impurity spin restricts this enhancement to the close vicinity of the impurity, whereas on all other sites the staggered magnetization gets suppressed compared to the clean case. Approaching the limit of an infinite coupling between host and impurity, the system hence crosses over to the case of an embedded non-magnetic impurity site. We compare our results with previous findings, based on spin-wave and perturbation theory.

TT 8.10 Mon 16:30 H 0104

Numerical investigation of the quantum dimer model on a diamond lattice — •Olga Sikora[1], Frank Pollmann[1], Nic Shannon[2], Karlo Penc[3], and Peter Fulde[1] — [1]Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany — [2]H.H. Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1 TL, UK — [3]Research Institute for Solid State Physics and Optics, H-1525 Budapest, P.O.B. 49, Hungary

Quantum dimer models (QDMs) are of great interest in the study of systems with frustrated spin or charge degrees of freedom. On bipartite lattices these QDMs can be mapped onto a U(1)-gauge theory, with a liquid-like ground state and fractional excitations. However in two dimensions, these excitations are confined, except at the Rokhsar-Kivelson (RK) point, a quantum critical point occurring for one specific ratio of parameters. Recently, it has been suggested that in the QDM on a 3D diamond lattice, a U(1) liquid is not confined to a single point, but extends for a finite range of parameters bordering the RK point.

We have used Green's Function Monte Carlo (GFMC) and Variational Monte Carlo simulations to test this conjecture numerically. Our preliminary GFMC calculations suggest that the confining potential for fractional excitations vanishes in a large region of the parameter space, confirming the existence of an extended liquid phase.

15 min. break

TT 8.11 Mon 17:00 H 0104

Spectral functions of kagome lattice structures with charge degrees of freedom — •Aroon O'Brien, Frank Pollmann, and Peter Fulde — Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany

Systems in which strong electronic interactions are frustrated can exhibit interesting physical effects. Two particularly well known frustrated lattices are the planar pyrochlore (checkerboard) lattice and the kagome lattice. For a model of spinless fermions on a checkerboard lattice, it has been demonstrated that fractional charges occur at certain filling factors [1]. A thorough study of this model has further shown that these fractional charges are linearly confined [2]. However, whether fractional charges are confined or deconfined at various fillings on the kagome lattice is not yet understood. We address this question through the numerical calculation of various properties of static and dynamic fractional charges at 1/3 and 1/6 filling, for a model of spinless fermions on the kagome lattice.

[1] P. Fulde, K.Penc, and N. Shannon, Annalen der Physik (Leipzig) **11**, 892 (2002)

[2] F. Pollmann and P. Fulde, EPL 75, 133 (2006)

TT 8.12 Mon 17:15 H 0104

Supersolid phase induced by correlated hopping in spin-1/2 frustrated quantum magnets — •Kai P. Schmidt[1], Julien Dorier[1], Andreas Laeuchli[2], and Frederic Mila[1] — [1]Institute of Theoretical Physics, Ecole Polytechnique Federale de Lausanne, CH-1015 Lausanne, Switzerland — [2]Institut Romand de Recherche Numerique en Physique des Materiaux (IRRMA), CH-1015 Lausanne, Switzerland

We show that correlated hopping of triplets, which is often the dominant source of kinetic energy in dimer-based frustrated quantum magnets, produces a remarkably strong tendency to form supersolid phases in a magnetic field. These phases are characterized by simultaneous modulation and ordering of the longitudinal and transverse magnetization respectively. Using Quantum Monte Carlo and a semiclassical approach for an effective hard-core boson model with nearest-neighbor repulsion on a square lattice, we prove in particular that a supersolid phase can exist even if the repulsion is not strong enough to stabilize an insulating phase at half-filling. Experimental implications for frustrated quantum antiferromagnets in a magnetic field at zero and finite temperature are discussed.

TT 8.13 Mon 17:30 H 0104

Spinon confinement and the Haldane gap in SU(n) spin chains: numerical studies — •Max Führinger[1], Stephan Rachel[1], Ronny Thomale[1], Peter Schmitteckert[1,2], and Martin Greiter[1] — [1]Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe

Recently, two of us [1] motivated a general set of rules which SU(n) spin chains exhibit spinon confinement and hence a Haldane gap in the spectrum. According to these rules, models of spin chains with SU(n) spins transforming under a representation corresponding to a Young tableau consisting of a number of boxes λ which is divisible by n, are gapped. If λ and n have no common divisor, the spin chain will support deconfined spinons and not exhibit a Haldane gap. If λ and n have a common divisor different from n, it will depend on the specifics of the model including the range of the interaction.

Here we present numerical evidence for these rules, obtained by exact diagonalization and DMRG, using the representations **3**, **6**, **8**, and **10** of SU(3) and the representations **4**, **6**, and **10** of SU(4). The numerical data obtained include the low energy spectra and results for bond and entanglement entropies. The entanglement entropy yields the central charge of the critical models as well.

[1] M. Greiter and S. Rachel, Phys. Rev. B **76**, 184441 (2007).

TT 8.14 Mon 17:45 H 0104

Field-dependent thermal transport in the Haldane chain compound NENP — •A. V. Sologubenko[1], T. Lorenz[1], J. A. Mydosh[1], and M. M. Turnbull[2] — [1]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany — [2]Carlson School of Chemistry and Department of Physics, Clark University, Worcester, MA 01610, USA

Properties of materials in the vicinity of quantum phase transitions have recently attracted considerable attention. Of particular interest are low-dimensional magnetic systems with transitions between various gapless and gapped states, induced by an external magnetic field. We present experiments on the magnetic field dependent thermal transport in the spin $S = 1$ chain material $Ni(C_2H_8N_2)_2NO_2(ClO_4)$ [NENP]. In NENP, the Haldane energy gap in the magnon excitation spectrum can be greatly reduced by applying an external magnetic field, but it remains finite at the critical field. The thermal conductivity is strongly affected by the field-induced changes in the magnon spectrum. It is possible to clearly distinguish the magnetic and the phononic contributions to the total heat conductivity and to successfully analyze the spin contribution in terms of a quasiparticle model. The mean free path of the spin excitations, evaluated from our data, is temperature-independent and large, which has important implications for the theory of transport in quantum spin systems.

Supported by the Deutsche Forschungsgemeinschaft through SFB 608.