TT 3: Correlated Electrons: Spin Systems and Itinerant Magnets 1

Time: Monday 10:15–13:00 Location: HSZ 304

TT 3.1 Mon 10:15 HSZ 304

Plaquette order in the J_1-J_2-J_3 model: a series expansion analysis — •Wolfram Brenig[1] and Marcelo Arlego[2] — [1]Institut für Theoretische Physik, Technische Universität Braunschweig, Germany — [2]Departamento de Física, Universidad Nacional de La Plata, Argentina

Series expansion based on the flow equation method is employed to study the zero temperature properties of the spin-1/2 J_1-J_2-J_3 antiferromagnet in two dimensions. Starting from the exact limit of decoupled plaquettes in a particular generalized J_1-J_2-J_3 model we analyze the evolution of the ground state energy and the elementary triplet excitations in powers of all three inter-plaquette couplings up to fifth order. We find the plaquette phase to remain stable over a wide range of exchange couplings and to connect adiabatically up to the case of the plain J_1-J_2-J_3 model, however not to the J_1-J_2 model at $J_3 = 0$. This corroborates other recent predictions. Additionally we estimate the extent of the plaquette phase by Dlog-Padé analysis of the critical lines that result from closure of the triplet gap.

TT 3.2 Mon 10:30 HSZ 304

DMRG Study of Anisotropic Triangular Heisenberg Lattice — •Andreas Weichselbaum[1,2] and Steven R. White[2] — [1]Ludwig-Maximilians-Universität, Lehrstuhl Jan von Delft, 80333 München — [2]University of California, Irvine, CA 92697, USA

The anisotropic antiferromagnetic two-dimensional triangular Heisenberg lattice for spin 1/2 describes certain classes of transition-metal oxides (TMOs) and chalcogenides (TMCs), clearly supported by experimental data. The understanding of the ground state properties of this kind of system from a theoretical point of view, however, has remained an extraordinary challenge. In the model under consideration, quasi-one-dimensional Heisenberg chains of uniform intrachain coupling strength J interact with their neighboring chains via the interchain coupling J'. By varying the anisotropy ratio $j \equiv J'/J$ from $j = 0$ (decoupled Heisenberg chains) to $j = 1$ (uniform triangular lattice with finite Neel order like local magnetization), it was pointed out in previous studies [1] that, indeed, there appears to exist spin liquid properties up to remarkably high values of j of about 0.85. We put these partially conjectured results under scrutiny by applying DMRG on finite systems with cylindrical boundary conditions specifically optimized to reduce finite size effects [2].

[1] S. Yunoki et al., PRB **74**, 014408 (2006).
[2] S. R. White et al., PRL **99**, 127004 (2007).

TT 3.3 Mon 10:45 HSZ 304

Effects of Dzyaloshinskii-Moriya interactions and non-magnetic impurities on the $S = 1/2$ Kagomé antiferromagnet — Ioannis Rousochatzakis[1], •Salvatore R. Manmana[1], Andreas M. Läuchli[2], Bruce Normand[3], and Frédéric Mila[1] — [1]Institute of Theoretical Physics (CTMC), EPF Lausanne, Schweiz — [2]MPI-PKS, Dresden, Germany — [3]Institute of Theoretical Physics, ETH Zürich, Schweiz

Motivated by recent NMR experiments[1] on $ZnCu_3(OH)_6Cl_2$, we present an exact diagonalization study of the combined effect of non-magnetic impurities and Dzyaloshinskii-Moriya (DM) interactions in the $S = 1/2$ Kagomé antiferromagnet. The magnetization response and the correlation matrix data reveal that the dimer freezing which occurs around the vacancy for $D = 0$ [2] (D is the magnitude of the DM vectors) persists up to $D/J \simeq 0.07$, above which a phase transition to the $(Q = 0)$ semiclassical 120° state[3] takes place. Surprisingly however, the dimers next to the vacancy remain strong up to $D/J \sim 1-3$, i.e. well above the critical point. Implications for $ZnCu_3(OH)_6Cl_2$ will be discussed.

[1] A. Olariu, *et al.* , Phys. Rev. Lett. **100**, 087202 (2008).
[2] S. Dommange, *et al.*, Phys. Rev. B **68**, 224416 (2003);
A. Läuchli, *et al.*, Phys. Rev. B **76**, 144113 (2007).
[3] O. Cépas, *et al.*, Phys. Rev. B **78**, 140405 (2008).
[4] S. Miyahara, *et al.*, Phys. Rev. B **75**, 184402 (2007).

TT 3.4 Mon 11:00 HSZ 304

Dynamical properties of kagome lattice models with charge degrees of freedom — •Aroon O'Brien[1], Frank Pollmann[2], and Peter Fulde[1,3] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany — [2]University of California, Berkeley, CA94720, USA — [3]Asia Pacific Center for Theoretical Physics, Pohang, Korea

Systems with frustrated interactions are typically characterized by a high density of low-lying excitations, leading to fascinating phenomena such as fractionalization. We study how charge degrees of freedom give rise to fractional charges in such systems.

For a spinless fermion model on a 2D checkerboard lattice, it is known that confined fractional charge excitations occur at certain filling factors. However, charge fractionalization, in the case of another 2D frustrated lattice, the kagome lattice, is not so thoroughly understood. We investigate, through the calculation of spectral functions, models of spinless fermions and hardcore bosons respectively, at 1/3 filling on finite kagome lattices. Of particular interest is the strongly correlated limit, where excitations carrying fractional charges can occur. We derive an effective model pertaining to this regime and present our findings in relation to a quantum dimer model on the hexagonal lattice. We find that the effective Hamiltonian is bipartite, allowing us to determine a gauge transformation which cures the negative sign problem. We discuss further results through the comparison of the dynamical properties of the bosonic and fermionic models.

TT 3.5 Mon 11:15 HSZ 304

Numerical evidence of a U(1) liquid phase in the quantum dimer model on a diamond lattice — •Olga Sikora[1], Frank Pollmann[2], Nic Shannon[3], Karlo Penc[4], and Peter Fulde[1,5] — [1]Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany — [2]Department of Physics, University of California, Berkeley, CA94720, USA — [3]H.H. Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1TL, UK — [4]Research Institute for Solid State Physics and Optics, H-1525 Budapest, P.O.B. 49, Hungary — [5]Asia Pacific Center for Theoretical Physics, Pohang, Korea

Quantum dimer models (QDMs) are widely studied as effective models for many different condensed matter systems. Recently, it has been suggested that in the QDM on a bipartite lattice in 3D, a U(1) liquid extends for a finite range of parameters bordering the "Rokhsar-Kivelson" (RK) point [1,2]. We have used large-scale Green's function Monte Carlo simulations to establish the complete zero-temperature phase diagram for a QDM on a diamond lattice. Our results confirm explicitly the existence of the three phases conjectured for this model — a 16-sublattice ordered "R state" with cubic symmetry, a set of isolated states and, separating them, a U(1) liquid phase terminating at the RK point. Notably, our results for the liquid phase reproduce the energy spectra predicted by the corresponding U(1) theory.

[1] R. Moessner and S.L. Sondhi, Phys. Rev. B **68**, 184512 (2003).
[2] D.L. Bergman, G.A. Fiete, and L. Balents, Phys. Rev. B **73**, 134402 (2006).

15 min. break

TT 3.6 Mon 11:45 HSZ 304

Skyrmion Lattice in MnSi — Sebastian Mühlbauer[1,2], Benedikt Binz[3], Florian Jonietz[1], •Christian Pfleiderer[1], Achim Rosch[3], Andreas Neubauer[1], Robert Georgii[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]ITP, University of Cologne, Zülpicher Str. 77, D-50937 Cologne, Germany

Skyrmions represent topologically stable field configurations with particle-like properties. We use neutron scattering to observe the spontaneous formation of a two-dimensional lattice of skyrmion lines, a type of magnetic vortices, in the chiral itinerant-electron magnet MnSi. The skyrmion lattice stabilizes at the border between paramagnetism and long-range helimagnetic order perpendicular to a small applied magnetic field – regardless of the direction of the magnetic field relative to the atomic lattice. Our study experimentally establishes magnetic materials lacking inversion symmetry as an arena for new forms of crystalline order composed of topologically stable spin states.

TT 3.7 Mon 12:00 HSZ 304

Spin Torque Effects in a Helical Magnet — •Florian Jonietz[1], Sebastian Mühlbauer[1,2], Christian Pfleiderer[1], Rembert Duine[3], Benedikt Binz[4], Achim Rosch[4], Andreas Neubauer[1], Robert Ritz[1], Stefan Legl[1], Wolfgang Münzer[1], Robert Georgii[2], and Peter Böni[1] — [1]Physik Department E21, Technische Universität München — [2]Forschungsneutronenquelle Heinz Maier-Leibnitz FRM II — [3]Institute for Theoretical Physics, Utrecht University — [4]ITP, University of Cologne

Spin torque interactions in soft ferromagnets are a promising route to novel spintronics devices. In these systems the spin torque is due to changes of the orientation of the spin-polarization of the conduction electrons in non-colinear spin structures, notably Bloch domain walls. A major constraint of these studies is the extrinsic nature of magnetic pinning in soft ferromagnets requiring very large current densities of order 10^{12} A/m^2. We report AC susceptibility and neutron scattering measurements in the A-Phase of MnSi, a two-dimensional skyrmion lattice [1], as a function of electric DC currents. The non-colinear spin structure is here intrinsic and due to Dzyaloshinsky-Moriya interactions, resulting in a very small pinning. We find distinct features that suggest spin torque effects at current densities that are 5 to 6 orders of magnitude smaller than those observed in soft ferromagnets. This identifies helical magnets as a new route to exploiting spin torque effects in novel spintronic applications.

[1] S. Mühlbauer, B. Binz, F. Jonietz, C. Pfleiderer, A. Rosch, R. Georgii, P. Böni, in review (2008)

TT 3.8 Mon 12:15 HSZ 304

Skyrmion Lattice in $Fe_{1-x}Co_xSi$ — •Wolfgang Münzer[1], Christian Franz[1], Andreas Neubauer[1], Sebastian Mühlbauer[1], Tim Adams[1], Florian Jonietz[1], Christian Pfleiderer[1], Benedikt Binz[2], Achim Rosch[2], Robert Georgii[3], Peter Böni[1], Martin Schmid[4], and Juri Grin[4] — [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]ITP, University of Cologne, Zülpicher Str. 77, D-50937 Cologne, Germany — [4]Max Planck Institut für Chemische Physik fester Stoffe, 01187, Dresden, Germany

The recent identification of the A-phase in MnSi as a hexagonal lattice of anti-skyrmions raises the question, if skyrmion lattice ground states exist in further members of the series of B20 transition metal compounds. We have grown single crystals of selected compositions in the series $Fe_{1-x}Co_xSi$ by means of vapor transport and optical float zoning. Our samples are consistent with the previously reported temperature versus composition phase diagram. Comprehensive neutron scattering and magneto-transport measurements establish an extremely rich magnetic phase diagram of skyrmion phases as a function of magnetic field strength, temperature and direction.

TT 3.9 Mon 12:30 HSZ 304

Inelastic neutron scattering study of helimagnons in MnSi — •Marc Janoschek[1,2], Florian Jonietz[1], Sarah Dunsiger[1], Christian Pfleiderer[1], Peter Böni[1], Bertrand Roessli[2], Peter Link[3], and Achim Rosch[4] — [1]Physik Department E21, Technische Universität München, D-85748 Garching — [2]Paul Scherrer Institut, CH-5232 Villigen PSI — [3]Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM-II), Technische Universität München, D-85748 Garching — [4]Institute of Theoretical Physics, Universität zu Köln, D-50937 Köln, Germany

In zero field the lack of inversion symmetry in MnSi results in a weak Dzyaloshinsky-Moriya interaction, that stabilises a spin spiral with a period of approximately 180Å below $T_c = 29.5$ K. Recent theoretical studies [1,3] predict a rich spectrum of Goldstone modes in the helical phase for wave vectors that are small compared to the helical propagation vector. These excitations, also referred to as helimagnons, are predicted to have a characteristic anisotropic dispersion relation with respect to the propagation direction of the spiral. We have performed extensive inelastic neutron scattering experiments by means of triple-axis spectroscopy in order to explore the nature of these excitations. The measurements have been carried out in the helical phase and in the A-phase where a skyrmion lattice has been observed recently[3].

[1] D. Belitz, T. R. Kirkpatrick and A. Rosch Phys. Rev. B 73, 054431 (2006).
[2] S. V. Maleyev, Phys. Rev. B 73, 174402 (2006).
[3] S. Mühlbauer, B. Binz, F. Jonietz, C. Pfleiderer, A. Rosch, A. Neubauer, R. Georgii, P. Böni, (2008).

TT 3.10 Mon 12:45 HSZ 304

Magnetic, electronic, and structural properties of the filled skutterudite $EuFe_4As_{12}$ — •Andreas Leithe-Jasper[1], Walter Schnelle[1], Helge Rosner[1], Yuri Prots[1], Yuri Grin[1], Walter Steiner[2], and Michael Reissner[2] — [1]Max-Planck Institute for Chemical Physics of Solids, Nöthnitzer Straße 40, 01187 Dresden, Germany — [2]TU Wien, Institut für Experimentalphysik, Wiedner Hauptstraße 8–10, 1040 Wien, Austria

The europium iron arsenide $EuFe_4As_{12}$ with filled skutterudite structure has been synthesized and its structural, electronic, magnetic and thermodynamic properties have been investigated. The Fe and Eu moments order ferrimagnetically at $T_C = 151$ K, the highest magnetic ordering temperature among filled skutterudite compounds. LDA band structure calculations confirm the observed magnetic polarizations and suggest that conduction electrons in $EuFe_4As_{12}$ have a large spin polarization, albeit lower than in isostructural $EuFe_4Sb_{12}$.