TT 7: Correlated Electrons: Spin Systems, Itinerant Magnets 1

Time: Monday 9:30–13:00 Location: H19

TT 7.1 Mon 9:30 H19

Eigenstate thermalization in isolated spin-chain systems — •Robin Steinigeweg[1,2], Jacek Herbrych[2], and Peter Prelovšek[2] — [1]Institute for Theoretical Physics, Technical University Braunschweig, D-38106 Braunschweig — [2]Department of Theoretical Physics, Jožef Stefan Institute, SI-1000 Ljubljana

The thermalization phenomenon and many-body quantum statistical properties are studied on the example of several observables in isolated spin-chain systems, both integrable and generic non-integrable ones. While diagonal matrix elements for non-integrable models comply with the eigenstate thermalization hypothesis, the integrable systems show evident deviations and similarity to properties of noninteracting many-fermion models. The finite-size scaling reveals that the crossover between two regimes is given by a scale closely related to the scattering length. Low-frequency off-diagonal matrix elements related to d.c. transport quantities also follow in a generic system a behavior analogous to the eigenstate thermalization hypothesis, however unrelated to the one of diagonal elements.

TT 7.2 Mon 9:45 H19

Emergent critical phase and Ricci flow in a 2D frustrated Heisenberg model — •Peter Orth[1], Premala Chandra[2], Piers Coleman[2], and Jörg Schmalian[1] — [1]Institute for Theoretical Condensed Matter Physics, Karlsruhe Institute of Technology (KIT), 76128 Karlsruhe, Germany — [2]Center for Materials Theory, Department of Physics and Astronomy, Rutgers University, Piscataway, New Jersey 08854, USA

We introduce a two-dimensional frustrated Heisenberg antiferromagnet on interpenetrating honeycomb and triangular lattices [1]. Classically the two sublattices decouple, and "order from disorder" drives them into a coplanar state. Applying Friedan's geometric approach to nonlinear sigma models, we obtain the scaling of the spin-stiffnesses governed by the Ricci flow of a 4D metric tensor. At low temperatures, the relative phase between the spins on the two sublattices is described by a six-state clock model with an emergent critical phase and two Berezinskii-Kosterlitz-Thouless (BKT) phase transitions.

[1] P. P. Orth, P. Chandra, P. Coleman, and J. Schmalian, arXiv:1206.5740v1 (2012) (accepted for Phys. Rev. Lett.)

TT 7.3 Mon 10:00 H19

Doping effects on Honeycomb lattice iridate A_2IrO_3 (A=Na,Li) — •Soham Manni[1], Yogesh Singh[2], and Philipp Gegenwart[1] — [1]I. Physikalisches Institut, Georg-August-Universitaet Goettingen, Goettingen, Germany — [2]IISER Mohali, Mohali, India

Iridates have recently attracted much attention due to a novel $S_{\text{eff}} = 1/2$ Mott insulating state, driven by the interplay of moderate electronic correlations with strong spin-orbit coupling. We focus on A_2IrO_3 (A=Na,Li) which is a layered system with Ir moments sitting on a Honeycomb lattice [1, 2]. Theoretically, this system has been proposed as solid-state realization of the Heisenberg-Kitaev(HK)model. Recently there are many fascinating predictions for doping in A_2IrO_3 [3].

The temperature dependence of the susceptibility indicates a dominating antiferromagnetic exchange interaction with $\Theta_W = -125$ K and -33 K for the Na- and Li- system, respectively, while $T_N = 15$K for both materials. We discuss the effects of different dopings (iso- and non-isoelectronic) on the A-site and Cu-intercalation by investigation of their structural, electronic and magnetic properties. Different playgrounds like order-disorder effect and chemical pressure effect etc. will be discussed here.

Work supported by the Erasmus Mundus EURINDIA project.

[1] Y. Singh and P. Gegenwart, Phys. Rev. B 82, 064412 (2010)
[2] Y. Singh, S. Manni, P. Gegenwart and others, PRL 108, 127203 (2012)
[3] A. Vishwanath et.al. Phys. Rev. B 86, 085145 (2012).

TT 7.4 Mon 10:15 H19

Spin-liquid versus spiral-order phases in the anisotropic triangular lattice — •Luca F. Tocchio[1], Hélène Feldner[1], Federico Becca[2], Roser Valentí[1], and Claudius Gros[1] — [1]Institut für Theoretische Physik, Goethe-Universität Frankfurt am Main, Germany — [2]International School for Advanced Studies (SISSA) Trieste, Italy

We study the competition between magnetic and spin-liquid phases in the Hubbard model on the anisotropic triangular lattice, which is described by two hopping parameters t and t' in different spatial directions and is relevant for layered organic charge-transfer salts [1]. By using a variational approach that includes spiral magnetic order, we provide solid evidence that a spin-liquid phase is stabilized in the strongly-correlated regime and close to the isotropic limit $t'/t = 1$. Otherwise, a magnetically ordered spiral state is found, connecting the (collinear) Néel and the (coplanar) 120° phases. The pitch vector of the spiral phase obtained from the unrestricted Hartree-Fock approximation is substantially renormalized in presence of electronic correlations, and the Néel phase is stabilized in a wide regime of the phase diagram, i.e., for $t'/t < 0.75$. We discuss these results in the context of organic charge-transfer salts.

[1] B.J. Powell and R.H. McKenzie, Rep. Prog. Phys. 74, 056501 (2011)
[2] L.F. Tocchio, H. Feldner, F. Becca, R. Valentí, and C. Gros, arXiv:1209.1928

TT 7.5 Mon 10:30 H19

Lifshitz invariants and Z_2-vortex phase in the triangular lattice Kitaev-Heisenberg model — •Ioannis Rousochatzakis, Ulrich Rössler, Jeroen van den Brink, and Maria Daghofer — IFW Dresden, P.O. Box 27 01 16, D-01171 Dresden, Germany

We present our study on the classical Kitaev-Heisenberg Hamiltonian on a triangular lattice, and discuss the presence of an incommensurate non-coplanar phase, which is identified as a lattice of Z_2 vortices. The latter are topological point defects of the SO(3) order parameter in the continuum theory around the nearby Heisenberg antiferromagnet. The defects arise at zero temperature (in contrast to the well known entropic scenario [1]) due to a double-twisting mechanism that is generated by Lifshitz invariants related to spin-orbit coupling. In this respect, this phase is a Z_2 analog to the Z-vortex phases of type-II superconductors [2], the twisted grain boundary phases in liquid crystals [3], and to the Skyrmion lattice phases in chiral magnets [4].

[1] H. Kawamura and S. Miyashita, J. Phys. Soc. Jpn. **53**, 4138 (1984)
[2] A. A. Abrikosov, Sov. Phys. JETP **5**, 1174 (1957)
[3] S. R. Renn and T. C. Lubensky, Phys. Rev. A **38**, 2132 (1988)
[4] A. N. Bogdanov and D. A. Yablonskii, Sov. Phys. JETP **68**, 101 (1989); A. N. Bogdanov and A. Hubert, J. Magn. Magn. Mater. **138**, 255 (1994); U. K. Rößler, A. N. Bogdanov, and C. Pfleiderer, Nature **442**, 797 (2006)

TT 7.6 Mon 10:45 H19

$\mathbb{Z}_2$-vortex phase in a triangular-lattice Kitaev-Heisenberg model: Numerical simulations — Ioannis Rousochatzakis, Ulrich K. Rössler, Jeroen van den Brink, and •Maria Daghofer — IFW Dresden

We present numerical evidence for a $\mathbb{Z}_2$-vortex phase in the triangular-lattice Kitaev-Heisenberg model. We performed unbiased Monte-Carlo simulations and found at least two incommensurate phases: One of them is dominated by three incommensurate ordering vectors, one for each spin component, S^x, S^y and S^z. This phase hosts localized defects that are similar to skyrmions, but are here identified as $\mathbb{Z}_2$ vortices. The vortices are seen to form regular lattices that optimize their distance and whose lattice constant is determined by the incommensurate ordering vectors. For very large spin-orbit coupling, a different incommensurate phase emerges, where the symmetry between the three lattice directions (and spin components) is broken. One spin component dominates here and finite temperatures are characterized by nearly decoupled antiferromagnetic Ising chains, as in the square-lattice compass model. Connections to models for iridates will also be discussed.

[1] I. Rousochatzakis, U. K. Rössler, J. van den Brink, M. Daghofer, arXiv:1209.5895

15 min. break

TT 7.7 Mon 11:15 H19

Non-perturbative RG approach to frustrated magnets — •Nils Hasselmann[1] and Andreas Sinner[2] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart — [2]Institut für Physik, Theorie II, Universität Augsburg, 86135 Augsburg

Frustrated magnets support in two dimensions topological defects which for Heisenberg models are point-like and of Z_2 character. We analyse, using a Ginzburg-Landau-Wilson formulation and a non-local approximation of the interaction, frustrated magnets within the non-perturbative renormalization group approach. At low temperatures we recover the predictions of the usual non-linear sigma-model theory for frustrated magnets. However, in contrast to the usual non-linear sigma-model approach, but in agreement with Monte-Carlo simulations, we find in our approach clear signs of a defect unbinding transition at finite temperatures in frustrated Heisenberg models.

TT 7.8 Mon 11:30 H19

Strongly Correlated Fermions on a Kagome Lattice: Interplay between Spin and Charge Degrees of Freedom — •Krishanu Roychowdhury[1], Karlo Penc[2], Chisa Hotta[3], and Frank Pollmann[1] — [1]Max-Planck-Institute fur Physik of Komplexer Systeme, 01187 Dresden, Germany — [2]Research Institute for Solid State Physics and Optics, H-1525 Budapest, P.O.B. 49, Hungary — [3]Department of Physics, Faculty of Science, Kyoto Sangyo University, Kyoto 603-8555, Japan

We study strongly correlated electrons on a kagome lattice at 1/3 filling (i.e. two electrons per three sites). The dynamics is described by an extended Hubbard Hamiltonian. We are concerned with the limit |t|<<V<<U with hopping amplitude t, nearest-neighbour repulsion V and on-site repulsion U. In this limit, we can neglect double occupancy on the sites as well as states with more than two electrons per triangle. The low energy physics is described by an effective Hamiltonian which includes ring exchange of fermions around hexagons with amplitude g as well as an antiferromagnetic Heisenberg interaction with amplitude J. Using large scale exact-diagonalization, we observe a quantum-phase transition from a resonating plaquette phase at large g/J to a charge ordered phase at low values of g/J. To study the finite temperature physics, we consider a classical version of the problem in which we investigate the effects of a loop tension. This loop tension results from the spin-fluctuations and favours configurations with short loops.

TT 7.9 Mon 11:45 H19

Quantum phase transitions in coupled-dimer magnets: Systematic expansions and disorder — •Matthias Vojta — Technische Universität Dresden, Germany

Quantum phase transitions in quantum magnets, with coupled-dimer systems being prominent examples, have been extensively studied both experimentally and theoretically. A standard microscopic approach to coupled-dimer Hamiltonians is the bond-operator technique of Sachdev and Bhatt, which has been widely applied to describe Gaussian magnetic fluctuations. Here we describe extensions of the method in two directions: (i) systematic expansions beyond the Gaussian level, and (ii) the inclusion of quenched disorder. In both cases, we focus on the evolution across the transition using suitable bosonic condensates. Among other things, we address (i) the consistent implementation of Goldstone's theorem, and (ii) the excitation spectrum of quantum Griffiths phases.

TT 7.10 Mon 12:00 H19

Singular field response and singular screening of vacancies in antiferromagnets — •Alexander Wollny, Eric C. Andrade, and Matthias Vojta — Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden

For isolated vacancies in ordered local-moment antiferromagnets we show that the magnetic-field linear-response limit is generically singular: The magnetic moment associated with a vacancy in zero field is different from that in a finite field h in the limit $h \to 0^+$. The origin is a universal and singular screening cloud, which moreover leads to perfect screening as $h \to 0^+$ for magnets which display spin-flop bulk states in the weak-field limit.

TT 7.11 Mon 12:15 H19

Electric Field Response of Coulombic Charge Ice — •Paul McClarty[1], Aroon O'Brien[2], Frank Pollmann[1], and Roderich Moessner[1] — [1]MPI PKS, Noethnitzer Strasse 38, 01187, Dresden, Germany — [2]School of Physics, University of Sydney, Sydney, Australia

Coulomb phases are states of matter which arise in certain geometrically frustrated systems. They are characterized by an emergent low energy gauge freedom which entails the existence of particular anisotropic correlations and fractionalized excitations. The archetypal example of such a state of matter is the spin ice state which appears in some rare earth magnets. Here we consider a manifestation of a Coulomb phase in a model inspired by certain mixed valence ferrites including magnetite. In zero field, we were able to treat this Coulombic charge ice model and the dipolar spin ice model on an equal footing by mapping both to a constrained charge model on the diamond lattice. We found that states of the two ice models are related by a staggering field which is reflected in the energetics of these two models. In this talk, we focus on the screening, within the Coulomb phase, of the long range interaction and the response of charge ice to a static external electric field.

TT 7.12 Mon 12:30 H19

Anormalous dynamics of electric dipoles on magnetic monopoles in spin ice — •Christoph Grams, Martin Valldor, and Joachim Hemberger — II. Physikalisches Institut, Universität zu Köln, Cologne, Germany

The coupling of electric dipoles to magnetic monopoles [1] enables us to see magnetic monopoles with dielectric spectroscopy. Therefore we can use our setup in the dilution cryostat to evaluate monopole dynamics in $Dy_2Ti_2O_7$ in a frequency range up to 1 MHz with magnetic and electric field parallel to the [111] direction of the sample down to 100 mK.

Our measurements show an anomaly in the monopole dynamics in a conic area in the (H,T) phase diagram above the critical endpoint (approximately 400 mK and 1 T) of the first order monopole liquid-gas transition [2]. Repeating the measurements with the electric field perpendicular to the magnetic field the abnormal dynamics vanish, indicating an anisotropy of the polarization and thereby promoting the idea of antiferroelectric order in the high field phase.

Work supported by the DFG through SFB 608.

[1] D. I. Khomskii, Nature Commun. 3, 1-13 (2012)
[2] C. Castelnovo et al., Nature 451(7174), 42-5 (2008)

TT 7.13 Mon 12:45 H19

Anisotropic magnetic Heat Transport in the Spin-Ice Compound $Dy_2Ti_2O_7$ — •Simon Scharffe, Gerhard Kolland, Oliver Breunig, Martin Hiertz, Martin Valldor, and Thomas Lorenz — II. Physikalisches Institut, Universität zu Köln, Germany

The spin-ice compound $Dy_2Ti_2O_7$ is a geometrically frustrated spin system which recently attracted attention due to emerging magnetic monopoles. It consists of corner-sharing Dy^{3+} tetrahedra which form a pyrochlore lattice. Due to strong crystal field effects an Ising anisotropy is present which aligns the Dy^{3+} spins along their local easy-axis in the {111}-directions, pointing into or out of the tetrahedra. The ground state below 1 K is given by the "ice-rule": two spins point into and two out of a tetrahedron. Excited states can be created by flipping one spin, leading to neighboring "1-in/3-out" and "3-in/1-out" configurations. In zero magnetic field, these excitations can deconfine and are discussed as magnetic monopoles. Recently, κ has been studied for $\vec{B}||[001]$ and gives evidence for considerable monopole heat transport [1]. Here, we focus on the magnetic field anisotropy of κ_{mag} as for $\vec{B}||[110]$ and $\vec{B}||[111]$ exotic ground states of different degeneracies can be stabilized. In order to separate the phononic and magnetic contribution to κ, we also investigated $(Dy_{0.5}Y_{0.5})_2Ti_2O_7$ which is a magnetic reference system with suppressed spin-ice features.

This work was supported by the DFG through SFB 608.

[1] Kolland *et. al.* (2012), PRB, **86**(060402)