MA 33: Frustrated Magnets I

Time: Wednesday 15:00–17:15 Location: HSZ 403

MA 33.1 Wed 15:00 HSZ 403

Frequency-resolved functional renormalization group for quantum magnetic systems — •Janik Potten, Tobias Müller, and Ronny Thomale — Julius-Maximilians-Universität, Würzburg, Deutschland

Strongly correlated materials are one of the most prolific topics of contemporary condensed matter physics. Within this field, the functional renormalization group (FRG) approach for spin models relying on a pseudo-fermionic description has proven to be a very powerful technique in simulating ground state properties of strongly frustrated magnetic lattices. However, the FRG as well as many other theoretical models, suffer from the fact that they are formulated in the imaginary-time Matsubara formalism and thus are only able to predict static correlations directly. Nevertheless, describing the dynamical properties, especially of magnetic systems is one of the fundamental theoretical challenges, as they are the key to bridging the gap to experimental data from neutron scattering experiments. For the pseudo-fermion FRG, we remedy this shortcoming by establishing a methodical approach based on the Keldysh formalism, originally developed to handle non-equilibrium physics. This novel approach allows for calculating the dynamic properties of spin systems on arbitrary lattices. We can identify the correct low-energy behavior of the dynamic spin structure factors for examplary nearest neighbor Heisenberg systems. These first results are promising and extensions of this work might allow for an easy calculation of dynamic properties even for non-equilibrium magnetic systems in the future.

MA 33.2 Wed 15:15 HSZ 403

Spin functional renormalization group for the $J_1J_2J_3$ quantum Heisenberg model — Dmytro Tarasevych, •Andreas Rückriegel, Savio Keupert, Vasilios Mitsiioannou, and Peter Kopietz — Institut für theoretische Physik, Universität Frankfurt

We use our recently developed functional renormalization group (FRG) approach for quantum spin systems to investigate the phase diagram of the frustrated $J_1J_2J_3$ quantum Heisenberg model on a cubic lattice. From a simple truncation of the hierarchy of FRG flow equations for the irreducible spin-vertices which retains only static spin fluctuations and neglects the flow of the four-spin interaction, we can estimate the critical temperature with a similar accuracy as the numerically more expensive pseudofermion FRG. In the regime where the ground state exhibits either ferromagnetic or antiferromagnetic order, a more sophisticated truncation including the renormalization of the four-spin interaction as well as dynamic spin fluctuations reveals the underlying renormalization group fixed point and yields critical temperatures which deviate from the accepted values by at most 4%.

MA 33.3 Wed 15:30 HSZ 403

Thermal Hall conductivity near field suppressed magnetic order in a Kitaev Heisenberg model — •Aman Kumar and Vikram Tripathi — Tata Institute Of Fundamental Research, Mumbai, India

We investigate thermal Hall conductivity κ_{xy} of a J-K Kitaev-Heisenberg model with a Zeeman field in the (111) direction in the light of the recent debate surrounding the possible re-emergence of Ising topological order (ITO) and half-quantized κ_{xy}/T upon field-suppression of long-range magnetic order in Kitaev materials. We use the purification-based finite temperature Tensor Network approach making no prior assumptions about the nature of the excitations: Majorana, visons or spin waves. For purely Kitaev interactions and fields $h/K \gtrsim 0.02$ sufficient to degrade ITO, the peak κ_{xy}/T monotonously decreases from half-quantization associated with lower fields - a behavior reminiscent of vison fluctuation corrections. In our J-K model (with ferro-K and antiferro-J), in the vicinity of field-suppressed magnetic order, we found κ_{xy}/T to be significant, with peak magnitudes exceeding half-quantization followed by a monotonous decrease with increasing h. We thus conclude that half-quantized thermal Hall effect, if found in our model in the vicinity of field suppressed magnetic order, is a fine-tuning effect and is not associated with a Majorana Hall state with ITO.

MA 33.4 Wed 15:45 HSZ 403

Thermal spin dynamics of Kitaev magnets — •Oliver Franke — Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Deutschland

The honeycomb magnet α-$RuCl_3$ is a prime candidate material for realizing the Kitaev quantum spin liquid (QSL), but it shows long-range magnetic order at low temperature. Nevertheless, its broad inelastic neutron scattering (INS) response at finite frequency has been interpreted as that of a 'proximate QSL'. A moderate magnetic field indeed melts the residual zigzag order, giving rise to peculiar intermediate field phases before the high-field polarized state.

Are the scattering continua observed in experiments signatures of quantum fractionalized excitations in a QSL phase? Or are they caused by thermal fluctuations that break the large unit cell intermediate field phases predicted by theory? In this talk, I will present our recent study on the subject, which helps to answer these topical questions and highlights the importance of distinguishing finite temperature fluctuations from genuine quantum fractionalization signatures in frustrated magnets.

15 min. break

MA 33.5 Wed 16:15 HSZ 403

Disorder effects in the Kitaev-Heisenberg model — •Ayushi Singhania[1], Jeroen van den Brink[1,2], and Satoshi Nishimoto[1,2] — [1]Institute for Theoretical Solid State Physics, IFW Dresden, 01069 Dresden, Germany — [2]Department of Physics, Technical University Dresden, 01069 Dresden, Germany

We study the interplay of disorder and Heisenberg interactions in Kitaev model on honeycomb lattice. The effect of disorder on the transition between Kitaev spin liquid and magnetic ordered states as well as the stability of magnetic ordering is investigated. Using Lanczos exact diagonalization we discuss the consequences of two types of disorder: random-coupling disorder & singular-coupling disorder. They exhibit qualitatively similar effects in the pure Kitaev-Heisenberg model without long-range interactions. The range of spin liquid phases is reduced and the transition to magnetic ordered phases becomes more crossover-like. Furthermore, the long-range zigzag and stripy orderings in the clean system are replaced by their three domains with different ordering direction. Especially in the crossover range the coexistence of magnetically ordered and Kitaev spin-liquid domains is possible. Surprisingly, in presence of long range interactions, the stability of magnetic ordered state is diminished by singular-coupling disorder, and accordingly, the range of spin-liquid regime is extended. This mechanism may be relevant to materials like α-RuCl3 and H3LiIr2O6 where the zigzag ground state is stabilized by weak long-range interactions. We also find that the flux gap closes at a critical disorder strength and vortices appears in the flux arrangement.

MA 33.6 Wed 16:30 HSZ 403

$ZnCr_2Se_4$ as a spiral-spin-liquid approximant — •D. S. Inosov[1], Y. V. Tymoshenko[1], A. Akopyan[2], D. Shukla[2], N. Prasai[2], M. Doerr[1], D. Gorbunov[3], S. Zherlitsyn[3], D. J. Voneshen[4,5], M. Boehm[6], V. Tsurkan[7,8], V. Felea[8], A. Loidl[7], Y. O. Onykiienko[1], J. Ollivier[6], and J. L. Cohn[2] — [1]IFMP, TU Dresden — [2]University of Miami, Florida, USA — [3]Hochfeld-Magnetlabor Dresden-Rossendorf — [4]ISIS Facility, RAL, Didcot, UK — [5]Royal Holloway University of London, UK — [6]Institut Laue-Langevin, Grenoble, France — [7]Institute of Physics, University of Augsburg — [8]Institute of Applied Physics, Chisinau, Moldova

We investigated the cubic spinel helimagnet $ZnCr_2Se_4$ in its single-domain spin-spiral state by a combination of neutron scattering, thermal conductivity, ultrasound velocity, and dilatometry measurements. In zero magnetic field, the magnon spectrum consists of conventional gapless Goldstone modes and soft pseudo-Goldstone modes with a small energy gap of ∼0.17 meV. In an applied magnetic field, this gap closes nonmonotonically, so that upon reaching a critical field of 6 T, the gap vanishes over a whole 2D manifold in the reciprocal space. This was recently identified as a prerequisite for a putative spiral-spin-liquid ground state [see S. Gao *et al.*, Phys. Rev. Lett. **129**, 237202]. This highly unusual behavior of the spin gap causes large anomalies in thermal conductivity at subkelvin temperatures — nearly two orders of magnitude below the Néel temperature. Our results apply to a broad class of centrosymmetric Heisenberg helimagnets where discrete lattice symmetry is spontaneously broken by the magnetic order.

MA 33.7 Wed 16:45 HSZ 403

Magneto-elastic coupling and new phases in the Shastry-Sutherland compound NdB_4 discovered by high-resolution dilatometry — •Rahel Ohlendorf[1], Sven Spachmann[1], Lukas Fischer[1], Daniel Brunt[2], Jasper Linnartz[3], Steffen Wiedmann[3], Geetha Balakrishnan[2], Oleg Petrenko[2], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Department of Physics, University of Warwick, Coventry, UK — [3]HFML Nijmegen, Netherlands

We report high-resolution dilatometry studies on single crystals of the Shastry-Sutherland-lattice magnet NdB4 supported by specific heat and magnetometry data. The evolution of magnetically ordered phases below T_N = 17.2 K (commensurate antiferromagnetic phase), T_{IT} = 6.8 K (intermediate incommensurate phase), and T_{LT} = 4.8 K (low-temperature phase) is associated with pronounced anomalies in the thermal expansion coefficients. The data imply significant magneto-elastic coupling and evidence of a structural phase transition at T_{LT}. Grüneisen analysis of the ratio of thermal expansion coefficient and specific heat enables the derivation of uniaxial as well as hydrostatic pressure dependencies. From the observed anomalies the magnetic phase diagrams for B||c up to 15 T and for B||[110] up to 35 T are constructed. New in-field phases are discovered for both field directions and already known phases are confirmed. In particular, phase boundaries are unambiguously shown by sign changes of observed anomalies and corresponding changes in uniaxial pressure effects.

MA 33.8 Wed 17:00 HSZ 403

Emergent U(1) symmetry due to off-diagonal symmetric exchange interactions — •Sagar Ramchandani, Ciarán Hickey, and Simon Trebst — Institute for Theoretical Physics, University of Cologne, Germany

Frustrated magnetic systems are a result of competing interactions. These systems are of interest as they can exhibit a large ground state degeneracy, sometimes in the form of an emergent symmetry for the ground state.

Here, we study the effects of off-diagonal symmetric exchange interactions on classical O(3) spins on the Kagome lattice. We find an emergent U(1) symmetry in the ground state. We study the critical properties and the influence of thermal order-by-disorder on this symmetry using a combination of analytical and Monte Carlo methods.

The symmetry can be understood on the level of a single triangle. Using this understanding, we also propose a set of rules to generate a lattice model with these off-diagonal interactions that will exhibit the same emergent U(1) symmetry. The rules combine N triangles exhibiting N*U(1) symmetries into a single U(1) symmetry. These lattices can be generated in 1D, 2D & 3D.