MA 9: Cooperative Phenomena: Spin Structures and Magnetic Phase Transitions

Time: Monday 15:00–17:45 Location: HSZ 401

MA 9.1 Mon 15:00 HSZ 401

Spin functional renormalization group for dimerized quantum spin systems — Andreas Rückriegel, •Jonas Arnold, Raphael Goll, and Peter Kopietz — Institut für Theoretische Physik, Universität Frankfurt, Max-von-Laue Straße 1, 60438 Frankfurt, Germany

We investigate dimerized quantum spin systems using the spin functional renormalization group approach proposed by Krieg and Kopietz [Phys. Rev. B **99**, 060403(R) (2019)] which directly focuses on the physical spin correlation functions and avoids the representation of the spins in terms of fermionic or bosonic auxiliary operators. Starting from decoupled dimers as initial condition for the renormalization group flow equations, we obtain the spectrum of the triplet excitations as well as the magnetization in the quantum paramagnetic, ferromagnetic, and thermally disordered phases at all temperatures. Moreover, we compute the full phase diagram of a weakly coupled dimerized spin system in three dimensions, including the correct mean field critical exponents at the two quantum critical points.

MA 9.2 Mon 15:15 HSZ 401

Magnetic correlations in the presence of disorder in the Hubbard model — •Fabio Pablo Miguel Méndez-Córdoba[1,2,3], Joseph Tindall[4], Dieter Jaksch[2,5], and Frank Schlawin[2,3,6] — [1]Departamento de Física, Universidad de Los Andes, A.A. 4976, Bogotá, Colombia — [2]Universität Hamburg, Luruper Chaussee 149, Gebäude 69, D-22761 Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, Hamburg D-22761, Germany — [4]Center for Computational Quantum Physics, Flatiron Institute, 162 5th Avenue, New York, NY 10010 — [5]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, UK — [6]Max Planck Institute for the Structure and Dynamics of Matter, Luruper Chaussee 149, 22761 Hamburg, Germany

By selectively modifying hopping integrals in the triangular Hubbard model at half filling [1], we show that it is possible to change the ground state's spin angular momentum magnetization. We further demonstrate that this change does not appear in the corresponding effective Heisenberg model. The latter does not predict any magnetic coherence between distant sites [2]. Instead, higher-order interactions are required to anticipate the symmetry breaking that leads to the lifting of the degeneracy present in the Heisenberg model. Our results can be understood as an extension of Lieb's theorem to non-bipartite lattices [3].

[1] J. Tindall, et al., Phys. Rev. Lett. 125, 137001 (2020). [2] J. Strecka, et al., Phys. Rev. B 105, 064420 (2022). [3] E. H. Lieb, Phys. Rev. Lett. 62, 1201 (1989).

MA 9.3 Mon 15:30 HSZ 401

Subsequent Mott transitions and magnetic ground state in NiS_2 — •Jonas A. Krieger[1], Fabio Orlandi[2], Mikel I. Iñurrieta[3], Iñigo Robredo[3], Zaher Salman[4], Niels B. M. Schröter[1], Maia Garcia-Vergniory[3], Stuart S. P. Parkin[1], and Leslie Schoop[5] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Rutherford Appleton Laboratory, Didcot, UK — [3]Donostia International Physics Center, San Sebastián, Spain — [4]Paul Scherrer Institute, Villigen, Switzerland — [5]Princeton University, Princeton, USA

We present muon spin spectroscopy (μSR) measurements on the antiferromagnetic Mott insulator NiS_2. This compound features two subsequent magnetic phase transitions around 38.9K and 29K associated with the opening of a Mott gap. From the zero field and rotation dependence of transverse field μSR spectra we confirm the magnetic space group 205.33 in the 38.9K to 29K phase, determined from neutron diffraction [1]. We refine the muon stopping sites by using abinitio density functional theory (DFT) and show that the resulting 8c and 24d muon sites can fully explain the observed μSR precession frequencies. A disproportionate temperature evolution of the two frequencies associated with these sites points to the presence of a strong temperature dependence in the muon hyperfine coupling strength due to concomitant changes in the electronic structure. We then use the number of μSR frequencies in combination with complementary neutron diffraction results to identify the magnetic ground state.

[1] S. Yano, et al., Phys. Rev. B 93, 024409 (2016)

MA 9.4 Mon 15:45 HSZ 401

Magnetocrystalline anisotropies and quantum phase transitions in the cubic chiral magnets $Mn_{1-x}Fe_xSi$ and $Mn_{1-x}Co_xSi$ — •Vivek Kumar, Andreas Bauer, Marc Andreas Wilde, and Christian Pfleiderer — Physik-Department, Technische Universität München, D-85748 Garching, Germany

In the archetypical cubic chiral magnet MnSi, an extended regime of topological non-Fermi liquid behavior emerges without quantum criticality as magnetic order is suppressed by means of hydrostatic pressure [1]. Substitutional doping with iron or cobalt also results in the suppression of magnetic order, where quantum critical behavior is masked by the influence of disorder [2]. Recent small-angle neutron scattering studies suggested that in this context magnetocrystalline anisotropies may subtly but decisively influence the magnetic textures, however, no quantitative information was available [3]. Here, we report a study of a series of single crystals of $Mn_{1-x}Fe_xSi$ and $Mn_{1-x}Co_xSi$ by means of cantilever torque magnetometry. An analytic description that takes into account the tetrahedral point group of the cubic chiral magnets allows us to quantitatively infer anisotropy constants up to sixth-order in spin-orbit coupling and discuss their evolution as a function of temperature, magnetic field, and dopant concentration x.

[1] Pfleiderer *et al.*, Science **316**, 1871 (2007).
[2] Bauer *et al.*, Phys. Rev. B **82**, 064409 (2010).
[3] Kindervater *et al.*, Phys. Rev. B **101**, 104406 (2020).

15 min. break

MA 9.5 Mon 16:15 HSZ 401

Investigating the CMR Effect in $EuCd_2P_2$ by Means of Nonlinear Transport and Fluctuation Spectroscopy — •Marvin Kopp[1], Charu Garg[1], Sarah Krebber[1], Kristin Kliemt[1], Cornelius Krellner[1], Sudhaman Balguri[2], Fazel Tafti[2], and Jens Müller[1] — [1]Institute of Physics, Goethe-University Frankfurt, Frankfurt (Main), Germany — [2]Departments of Physics, Boston College, USA

The colossal magnetoresistance (CMR) effect has inspired extensive studies for decades and is still the subject of intense research due to its central place in the physics of correlated electron systems as well as its potential relevance for applications. Unlike the prototypical CMR compounds based on mixed valence and double exchange in manganites or a structural Jahn-Teller distortion and ferromagnetic ordering, we focus on $EuCd_2P_2$, that exhibits a strikingly large (10^4 %) negative MR significantly above its antiferromagnetic ordering temperature $T_N = 11$ K. Initial reports suggest that strong magnetic fluctuations within the layered structure could be responsible for the drastic change of resistance in the magnetic field [1]. In this work, we aim to investigate these fluctuations using higher harmonic resistance and resistance fluctuation (noise) spectroscopy. Higher harmonic measurements are sensitive to the small changes in magneto-electric coupling caused by the postulated forming of magnetic clusters (polarons), often hidden in standard resistance measurements. The dynamics of these magnetic clusters is studied using resistance noise spectroscopy as a function of temperature and magnetic field. [1] Adv. Mat., 2021, 33, 2005755.

MA 9.6 Mon 16:30 HSZ 401

Investigating the electronic charge and magnetic spin dynamics in the ferromagnetic semiconductor $HgCr_2Se_4$ using resistance fluctuation (noise) spectroscopy — •Charu Garg[1], Zhilin Li[2], Youguo Shi[2], and Jens Müller[1] — [1]Institute of Physics, Goethe University, 60438 Frankfurt (M), Germany — [2]Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190

The n-type $HgCr_2Se_4$ has been reported to exhibit a pronounced semiconductor-to-metal transition below and a CMR effect at the ferromagnetic transition at $T_C = 107$ K. Our recent study of charge carrier dynamics [Phys. Rev B 105, 064404 (2022)] suggests isolated magnetic polarons forming at $T > 2T_C$ which coalesce at T_C. In this talk, we discuss new results highlighting the strong correlation between the magnetic and electronic degrees of freedom that can lead to complex exchange pathways. Likely due to competing AF and FM interactions, we observe a distinctly slow decrease in resistance below the CMR transition. The striking dynamics of a distinct two-level fluc-

tuations superimposed on 1/f-type noise corroborates a slowing down of charge carrier and/or magnetic dynamics. Further, below 20 K, a strong upturn in resistance and simultaneously in resistance noise down to 500 mK is observed and is speculated to be linked to the emergence of spiral type magnetic order. Our results demonstrate that the presence of pronounced electron-spin correlations plays a key role in the unconventional temperature dependence of resistance and CMR effect in this spinel.

MA 9.7 Mon 16:45 HSZ 401

Field-induced magnetic excitations in phases II and II′ of $Ce_3Pd_{20}Ge_6$ — •Federico Mazza[1], Jakob Lass[2], Daniel Mazzone[2], Stewart Ross[3], Eun Sang Choi[4], Martin Nikolo[5], Xinlin Yan[1], Andrey Prokofiev[1], Silke Paschen[1], and Dmytro S. Inosov[6] — [1]TU Wien, Austria — [2]PSI, Villigen, Switzerland — [3]ISIS, Didcot, UK — [4]Florida State University, Tallahassee, USA — [5]St. Louis University, USA — [6]TU Dresden, Germany

$Ce_3Pd_{20}Ge_6$ is known for its unique quantum phase transitions between antiferromagnetic ordering phase III and ferroquadrupolar phases II and II′. Using torque magnetometry at subkelvin temperatures, we were able to map the phase diagram in field and momentum space, here we find the crossover between phases III-II′ at 1.5 T and II′-II at 8 T. In addition, with inelastic neutron scattering we investigate dispersive collective excitations with a strong magnetic field dependence for $\mathbf{B} \parallel (110)$, revealing a magnon soft mode (Goldstone mode) at (001) for phase III and (111) for phases II and II′. At 4 meV we discover the presence of two (CEF) excitations exhibiting a weak dispersion best seen in the $(HH1)$ direction. They are degenerate in the absence of magnetic field but split progressively as the field is increased.

MA 9.8 Mon 17:00 HSZ 401

Magnetoelastic coupling in the skyrmion lattice magnet $GdRu_2Si_2$ — •Lukas Gries[1], Daniel Mayoh[2], George Wood[2], Geetha Balakrishnan[2], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, Heidelberg University, Germany — [2]Department of Physics, University of Warwick, United Kingdom

We present high-resolution thermal expansion and magnetostriction studies on the centrosymmetric skyrmion-hosting tetragonal magnet $GdRu_2Si_2$ in high magnetic fields up to 15 T. Our data show magnetoelastic coupling associated with the onset of long-range antiferromagnet order in form of pronounced anomalies in thermal expansion and magnetostriction. We extract the uniaxial pressure dependencies of the different phase boundaries and discuss them in terms of spin-lattice coupling. Our data suggest additional phases in magnetic field and allow us to complement the previously published magnetic phase diagram.

MA 9.9 Mon 17:15 HSZ 401

Charge dynamics of heavy fermions near their quantum critical point — •Renjith Mathew Roy[1], Run Yang[1], Sooheyon shin[2], Seulki Roh[1], and Martin Dressel[1] — [1]1. Physikslisches Instiut, Universität stuttgart, Germany — [2]Laboratory for Multiscale Materials Experiments, Paul Scherrer Institut, Switzerland

Using infrared spectroscopy, we investigate the evolution of hybridization strength between the localized magnetic moments and itinerant electrons in heavy fermionic compound CeRh(In1-xSnx)5, with three different Sn concentrations, Sn 4.4%, Sn 6.9%, and 9.8% respectively. CeRhIn5 has an antiferromagnetic ground state, which is suppressed with Sn doping revealing a quantum-critical region. From our optical conductivity result, we report an enhancement of hybridization strength with increasing Sn concentration, and the observation of a non-Fermi liquid behaviour near the quantum critical point. The phase characterization was performed by magnetic susceptibility and resistivity measurements, which also support the non-Fermi liquid behavior observed near the quantum critical point.

MA 9.10 Mon 17:30 HSZ 401

Local structure of disordered $Fe_{60}V_{40}$ and the impact on its magnetism — •Simon Rauls[1], Benedikt Eggert[1], Shadab Anwar[2], Damian Günzing[1], Philipp Klassen[1], Tom Helbig[1], Rantej Bali[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Helmholtz-Zentrum Dresden-Rossendorf

Control of the structural order and nearest-neighbour interactions can provide a path to modify application relevant magnetic properties, such as the Gilbert damping. The binary alloy $Fe_{60}V_{40}$ shows an amorphous to polycrystalline phase transition, which can be triggered by annealing or ion irradiation. This phase transition also is a transition from a paramagnetic phase towards a ferromagnetic phase with very low Gilbert damping of ∼0.002 [1], which makes the material a promising candidate for the fabrication of embedded magnetic nanostructures in a single irradiation step. We want to highlight the results of our structural and magnetic investigations on $Fe_{60}V_{40}$ thin films, using EXAFS, magnetometry and Mössbauer spectroscopy, in order to understand the interconnection between the evolving ferromagnetism and nearest-neighbour interactions along the ion-irradiation induced phase transition.

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[1] S. Anwar et al. *ACS Appl. Electron. Mater.* 2022, **4**, 8 3860-3869