TT 65: Frustrated Magnets: General I

Time: Thursday 9:30–13:00 Location: H 2053

TT 65.1 Thu 9:30 H 2053

Elastocaloric Effect of the Shastry-Sutherland Compound $SrCu_2(BO_3)_2$ under Uniaxial Pressure — •Francisco Lieberich[1], Pascal Puphal[2], Ekaterina Pomjakushina[3], Andrew P. Mackenzie[1], and Elena Gati[1] — [1]MPI for Chemical Physics of Solids, Dresden, Germany — [2]MPI for Solid State Research, Stuttgart, Germany — [3]PSI, Villigen, Switzerland

$SrCu_2(BO_3)_2$ stands out as the prototypical system embodying the frustrated Shastry-Sutherland model, in which interacting dimers are arranged orthogonally on a square lattice. The intra- and inter-dimer interactions J and J' can be tuned by hydrostatic pressure, leading to a sequence of quantum phase transitions with increasing coupling ratio J'/J [1]. The application of uniaxial pressure holds the potential to break the lattice symmetry and thereby to extend the study of the Shastry-Sutherland model to the case of two inequivalent dimers. This generalized model is predicted to give rise to novel ground states [2]. To determine the entropic landscape of $SrCu_2(BO_3)_2$ under compressive uniaxial pressure up to $\sim$ 1GPa, we utilize measurements of the AC elastocaloric effect, a thermodynamic probe for investigating strain-tuned quantum materials [3]. We compare and contrast our results with the phase diagram under hydrostatic pressure [1] to disentangle the effects of symmetry-breaking and symmetry-conserving strains on the Shasty-Sutherland lattice.

Work supported by the DFG through SFB 1143.

[1] Guo et al., Phys. Rev. Lett. 124 (2020) 206602
[2] Boos et al., Phys. Rev. B 100 (2019) 140413(R)
[3] Ikeda et al., Rev. Sci. Instrum. 90 (2019) 083902

TT 65.2 Thu 9:45 H 2053

Strain-tuned change of the Young's modulus of the triangular antiferromagnet $PdCrO_2$ — •Nina Stilkerich[1,2], Tobias Ritschel[1], Seunghyun Khim[2], Andrew P. Mackenzie[2,3], Jochen Geck[1], and Clifford W. Hicks[2,4] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany — [3]Scottish Universities Physics Alliance (SUPA), School of Physics and Astronomy, University of St. Andrews, St. Andrews KY16 9SS, United Kingdom — [4]School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, United Kingdom

The delafossite $PdCrO_2$ is a frustrated antiferromagnet below its Neel temperature of 37.5K. Its triangular lattice can be compressed towards a square-like configuration with stress applied along the [-1 1 0] direction. Under high compression, a transition to Néel-type order is expected [1,2,3]. Here, we present a candidate for this transition discovered by stress-strain measurements. Related lattice changes were investigated in an in-house XRD+strain measurement. Combining both techniques, we report a substantial change in the Young's modulus across both the double-to-single-q and possible spiral-to-Neel transition, showing that magnetic interactions have a strong influence on the elastic moduli.

[1] D. Sun et al., New J. Phys. 23 (2021) 123050
[2] A.Yoshimori, J. Phys. Soc. Japan 14 (1959) 807
[3] J.Villain, J. Phys. Chem. Solids 11 (1959) 202

TT 65.3 Thu 10:00 H 2053

Investigation of magnetoelastic couplings on pyrochlore lattices up to B=162T saturation magnetic fields — •Nan Tang[1], Masaki Gen[2], Huiyuan Man[3], Kazuyuki Matsuhira[4], Akira Matsuo[5], Koichi Kindo[5], Akihiko Ikeda[6], Yasuhiro H. Matsuda[5], Philipp Gegenwart[1], Yoshimitsu Kohama[5], and Satoru Nakatsuji[3,5] — [1]Universität Augsburg, Augsburg, Germany — [2]RIKEN Center for Emergent Matter Science, Saitama,Japan — [3]The Johns Hopkins University, Maryland, USA — [4]Kyushu Institute of Technology, Fukuoka, Japan — [5]University of Tokyo, Chiba, Japan — [6]University of Electro-Communications, Tokyo, Japan

Magnetoelastic couplings are interesting due to their ability to generate nontrivial phenomena both of fundamental interest and technological significance. Hence, a comprehensive study based on both experiments and simulations acts as a valuable guide in disentangling the mechanism underlying material deformation. We will discuss magnetization and magnetostriction of two spin ices $Ho_2Ti_2O_7$ and $Pr_2Zr_2O_7$ up to B =162 T. For $Ho_2Ti_2O_7$, ΔL(B) passes a maximum around 40 T, in contrast to the monotonic behaviour of $Pr_2Zr_2O_7$. Our model based on point-charges and Born von Karman springs calculates the crystal-field striction and exchange striction, respectively, and the sum could explain the experiments well. These results showcase that magnetoelasticity in complicated frustrated magnets can be unraveled by very simple models.

TT 65.4 Thu 10:15 H 2053

Impact of magnetic frustration and site randomness on millikelvin adiabatic demagnetization refrigeration performance of rare-earth oxides — •Tim Treu[1], Prachi Telang[1], Marvin Klinger[1], Unnikrishnan Arjun[2], Anton Jesche[1], and Philipp Gegenwart[1] — [1]Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg — [2]Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore

Recently Ytterbium- and Gadolinium-oxide based frustrated magnets have been characterized as excellent millikelvin adiabatic demagnetization refrigerants. Compared to traditional paramagnetic hydrated salts, they offer several advantages: higher entropy density for similar minimal temperatures, chemical stability and UHV compatibility. We report a comparative study of various different Yb- and Gd-based oxides (including [1-4] and further unpublished results) and analyze the impact of geometrical frustration and site-randomness on their ADR performance.

Work supported by the German Research Foundation through project 514162746 (GE 1640/11-1).

[1] Y. Tokiwa et al., Commun. Mater. 2 (2021) 42
[2] A. Jesche et al., Phys. Rev. B 107 (2023) 104402
[3] U. Arjun et al., Phys. Rev. Applied 20 (2023) 014013
[4] U. Arjun et al., arXiv:2310.00961.

TT 65.5 Thu 10:30 H 2053

Spin-lattice coupling in Mn_3Ge and Mn_3Sn — •Aleksandr Sukhanov[1], Artem Korshunov[2], Nikita Andriushin[1], Alexei Bosak[2], and Marein Rahn[1] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, D-01069 Dresden — [2]European Synchrotron Radiation Facility (ESRF), BP 220, F-38043 Grenoble Cedex, France

Strong spin-lattice coupling in a material can be evidenced in spectroscopy by hybridization of magnons and phonons, which are quanta of spin excitations and crystal-lattice vibrations in ordered materials, respectively. In this case, an avoided crossing can be formed when the bare magnon and phonon dispersions intersect in reciprocal space at some momentum and energy.

The isostructural hexagonal compounds Mn_3Ge and Mn_3Sn are both characterized by a noncollinear spin order due to the geometric frustration of the kagome lattice formed by Mn ions. In this talk, we will discuss the results of our recent single-crystal inelastic x-ray scattering experiments on these two compounds. We were able to clearly resolve momenta and energy of the spin-lattice hybrid excitations in Mn_3Ge, whereas Mn_3Sn seem to show no signs of spin-lattice coupling in its spectra.

TT 65.6 Thu 10:45 H 2053

Anomalous critical exponents and other peculiarities of Li_2CuO4_2 — •Stefan-Ludwig Drechsler[1], Wolfram Lorenz[1], Ulrich K. Rössler[1], Roman Kuzian[2], Waldemar Hergett[3], and Rüdiger Klingeler[3] — [1]IFW-Dresden, Germany — [2]Intern. Phys. Center, San Sebastian, Spain — [3]Heidelberg University, Germany

We report anomalously small critical exponents for the sublattice magnetization of the critical exponent β for various single crystals of Li_2CuO_2 including recent data from the literature [1-3]. The obtained reduced values $\beta < 0.37$ as compared to the 3d-isotropic Heisenberg model are ascribed to a relevant magneto-elastic coupling especially along the c-axis and to the vicinity of a multicritical point to a non-collinear chiral phase resulting in the presence of Lifshits invariants (LI) in the free energy not yet considered so far for the highly symmetric lattice structure of Li_2CuO_2. The experimental Néel-temperature T_N is analyzed in terms of frustrating interchain couplings derived from a spin-wave analysis of inelastic neutron scattering data [1] leading to a sizable lowering by about 30%. Slightly different values for the

coupling constants as compared with [2] are interpreted in terms of a *two-phased* single crystal there leading to a sharp peak near 9.5 K and a broader shoulder near 9.1 K within a Fisher-plot for $d(T\chi(T))/dT$. Noteworthy is also a negative cusp near 2.5 K in the context of LI and weak ferromagnetism below 2.3 K.

[1] W.E.A. Lorenz *et al.*, EPL **88** (2009) 37002
[2] E. Zoghlin *et al.*, Phys. Rev. B **108** (2023) 064408
[3] E.M.L. Chung *et al.*, Phys. Rev. B **68** (2003) 144410

TT 65.7 Thu 11:00 H 2053

Specific heat of azurite up into the 1/3 magnetization plateau phase — •Carolin Kastner[1], Ralf Feyerherm[2], and Stefan Süllow[1] — [1]IPKM, TU Braunschweig, Germany — [2]HZB, Berlin, Germany

One dimensional frustrated quantum spin systems are a focus of extensive research efforts due to their exotic magnetic properties at low temperatures. The natural mineral azurite $Cu_3(CO_3)_2(OH)_2$ is one such material, reported as a model compound of the distorted diamond chain. In this system, the Cu^{2+} ions carry spin-1/2 moments that form monomers and dimers arranged as chains along the crystallographic b axis. An extended 1/3 magnetization plateau was observed to arise at around 11 T when the monomers are fully polarized.

We have investigated the specific heat of azurite up to 14 T to gain insight into the thermodynamic properties in the plateau phase. Below the magnetization plateau, the material exhibits long-range magnetic order, with the specific heat exhibiting a magnon gap behaviour $C_{\mathrm{mag}} \propto \exp \frac{-\Delta_m}{T}$. In the plateau phase, also a gap-like behaviour $C_{\mathrm{mag}} \propto \exp \frac{-\Delta_p}{T}$ is present. The parameters Δ_m, Δ_p seemingly disappear at the suppression of antiferromagnetic order of the monomer spins, possibly reflecting quantum critical behaviour.

15 min. break

TT 65.8 Thu 11:30 H 2053

Magnetic properties and phase diagram of triangular-lattice antiferromagnet $TlErSe_2$ — •Bastian Rubrecht[1], Mirtha Pillaca[2], Pritam Bhattacharyya[1], Liviu Hozoi[1], Dmitriy Efremov[1], Ellen Häussler[2], Thomas Doert[2], and Anja Wolter-Giraud[1] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW), Dresden, Germany — [2]Fakultät für Chemie und Lebensmittelchemie TU Dresden, Dresden, Germany,

The triangular-lattice (TL) antiferromagnet is a well-known case of strongly frustrated magnetism. Here, the delafossites, with the general chemical formula $A^{+I}RE^{+III}X_2$ (A: alkaline/monovalent cation, RE: rare-earth cation and X: chalcogen anion), offer a rich platform for exploring exotic magnetic phases arising from the degenerate ground state manifold.

By introducing different elements at the A site and choosing the magnetic rare-earth ion, one can tune the anisotropy of the magnetic interactions as well as the single-ion anisotropy, two defining parameters for the system's ground state.

In this study, we investigate $TlErSe_2$, a novel material realizing an antiferromagnetically coupled effective spin-1/2 model on a TL. Our zero-field ^{3}He specific heat studies revealed a phase transition at 0.42 K, which is successively suppressed with an increasing applied magnetic field. From magnetization and ^{3}He specific heat measurements on a polycrystalline $TlErSe_2$ sample, we construct the magnetic phase diagram and discuss the possible nature of the observed phases.

TT 65.9 Thu 11:45 H 2053

Magnon-phonon hybridization in the canted antiferromagnet $MnSc_2Se_4$ — •Jeremy Sourd[1], L Prodan[2], V Tsurkan[2], J Grumbach[3], M Dörr[3], A Miyata[4], T Gottschall[1], J Wosnitza[1,3], and S Zherlitsyn[1] — [1]Dresden High Magnetic Field Laboratory (HLD-EMFL), HZDR, Germany — [2]Institute for Experimental Physics, University of Augsburg, Germany — [3]Institute of Solid State and Materials Physics, TU Dresden, Germany — [4]Institute of Solid State Physics, University of Tokyo, Japan

The antiferromagnetic spinel compounds $MnSc_2X_4$ (X = S, Se) show extraordinary properties with various field induced phases due to their relatively small ordering temperature $T_N < 2.5$ K and saturation field $\mu_0 H_c < 15$ T. Thanks to the exchange-striction coupling between the localized $S = 5/2$ Mn^{2+} ions and the crystal lattice, ultrasound experiments permit to explore the $H - T$ phase diagram of this system in detail. Whereas $MnSc_2S_4$ shows a very rich phase diagram with a skyrmion phase induced by magnetic field, no transition is observed in $MnSc_2Se_4$ between the zero-field antiferromagnetic phase and the fully polarized state. Furthermore, our ultrasound data on $MnSc_2Se_4$ are qualitatively reproduced by a magnon-phonon hybridization term arising from exchange-striction coupling between the crystal lattice and canted spin-wave fluctuations.

TT 65.10 Thu 12:00 H 2053

Spin-1/2 Heisenberg diamond-like decorated honeycomb lattice in a magnetic field from the perspective of localized magnons and exact diagonalization — •Katarína Karľová[1], Jozef Strečka[2], Malo Rouxel[1], and Andreas Honecker[1] — [1]Laboratoire de Physique Théorique et Modélisation, CNRS UMR 8089, CY Cergy Paris Université, France — [2]Department of Theoretical Physics and Astrophysics, P.J. Šafárik University, Košice, Slovakia

The spin-1/2 quantum Heisenberg model on a two-dimensional diamond-like decorated honeycomb lattice is investigated by combining the analytical and numerical methods. The ground-state phase diagram of the investigated model includes besides fully polarized state, monomer-dimer phase, ferrimagnetic phase of Lieb-Mattis type, spin canted phase with a continuously rise of the magnetization with increasing of the magnetic field and macroscopically degenerate dimer-tetramer phase. It is shown that the localized-magnon approach based on a simple classical lattice-gas model of hard-core monomers provides a proper description of low-temperature magnetism and magnetothermodynamics of the investigated frustrated quantum spin system in a highly frustrated parameter region. The results obtained from the localized-magnon approach are corroborated by the exact numerical diagonalization of small-size systems as well as the density-matrix renormalization group calculations.

TT 65.11 Thu 12:15 H 2053

Continuous similarity transformation for critical phenomena: bilayer antiferromagnetic Heisenberg-model and $J_1 - J_2$-model — •Matthias R. Walther[1], Dag-Björn Hering[2], Götz S. Uhrig[2], and Kai P. Schmidt[1] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Institut für Theoretische Physik I, Staudtstraße 7, 91058 Erlangen — [2]Technische Universität Dortmund, Department of Physics, Condensed Matter Theory, Otto-Hahn-Str. 4, 44227 Dortmund

We apply continuous similarity transformations (CSTs) to the bilayer antiferromagnetic Heisenberg model and the antiferromagnetic $J_1 - J_2$ model on the square lattice. The bilayer Heisenberg model features a well studied, continuous phase transition in the O(3) universality class between a gapless Néel phase and a gapped paramagnetic dimer phase (valence bond solid). The $J_1 - J_2$ features a gapless Néel phase for $J_1 \gg J_2$, a gapless columnar phase for $J_2 \gg J_1$ and an intermediate phase whose nature is still under debate. We start in both models from the magnetically ordered, collinear phases and approach the quantum phase transitions by the melting of the long-range magnetic order. The CST flow equations are truncated in momentum space by the scaling dimension d so that all contributions with $d \leq 2$ are taken into account. This amounts up to tracking all linear and quadrilinear terms while neglecting hexatic and higher terms. We locate critical points and estimate critical exponents from the flow of the couplings, the ground-state magnetization and the ground-state energy.

TT 65.12 Thu 12:30 H 2053

Quantum phases of the XXZ model with repulsive dipolar Ising interactions on two-dimensional lattices — •Jan Alexander Koziol[1], Giovanna Morigi[2], and Kai Phillip Schmidt[1] — [1]Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany — [2]Theoretical Physics, Saarland University, Campus E2.6, D-66123 Saarbrücken, Germany

We analyse the ground-state quantum phase diagram of the XXZ model with repulsive dipolar Ising interactions on two-dimensional lattices. The ground state results from the interplay between the lattice geometry and the long-range interactions, which we account for by means of a classical spin mean-field approach. This extended classical spin mean-field theory accounts for the long-range Ising interaction without truncation. The mean-field analysis is limited by the size of the considered unit cells. We consider three different lattice geometries: square, honeycomb, and triangular. In the limit of zero XY-interactions the ground state is always a devil's staircase of solid (gapped) phases. Such crystalline phases with broken translational symmetry are robust with respect to finite hopping amplitudes. At intermediate XY-interactions, these gapped phases melt, giving rise to

various lattice supersolid phases, which can have exotic features with multiple sublattice densities. Our results are of immediate relevance for experimental realisations of self-organised crystalline ordering patterns, e.g., with ultracold dipolar atoms in an optical lattice.

TT 65.13 Thu 12:45 H 2053

Extracting quantum-critical properties from directly evaluated enhanced perturbative continuous unitary transformations — •Lukas Schamriss[1], Matthias R. Walther[1], Dag-Björn Hering[2], and Kai P. Schmidt[1] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstr. 7, 91058 Erlangen, Germany — [2]Condensed Matter Theory, TU Dortmund University, Otto-Hahn Str. 4, 44221 Dortmund, Germany

Ising models in a transverse field are paradigmatic models for quantum phase transitions of various universality classes depending on the lattice geometry and the choice of antiferromagnetic or ferromagnetic coupling. We investigate the quantum phase diagram of the bilayer antiferromagnetic transverse-field Ising model on the triangular lattice with an Ising-type interlayer coupling. Without a field, the model hosts a classically disordered ground state, and in the limit of decoupled layers it exhibits a 3dXY 'order by disorder' transition. Our starting point for the unknown parts of the phase diagram is a high-order perturbative calculation from the limit of isolated dimers. Directly evaluated enhanced perturbative continuous unitary transformations (deepCUTs) are used to calculate non-perturbatively extrapolated numerical data for the ground-state energy and the energy gap which coincide with the perturbative series up to the order with respect to which the deepCUT is truncated. We develop a general scheme to extract quantum critical properties from the deepCUT data based on critical scaling and a strict correspondence between the truncation used for deepCUT and the length scale of correlations at the critical point.