TT 49: Correlated Electrons: Low-dimensional Systems - Materials 4

Time: Friday 9:30–12:00 Location: H 3005

TT 49.1 Fri 9:30 H 3005

Crossover from 1D to 2D in the Infrared Absorption of Cuprate Ladder Systems — •Kris Cöster[1], Stefan Wessel[2], Eva Benckiser[3], Michael Voigt[4], Markus Grüninger[4], and Kai Phillip Schmidt[1] — [1]Lehrstuhl für Theoretische Physik I , TU Dortmund, 44221 Dortmund, Germany — [2]Institut für Theoretische Festkörperphysik, RWTH Aachen University, 52056 Aachen, Germany — [3]Max-Planck-Institut für Fest körperforschung, 70569 Stuttgart, Germany — [4]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany

We study the optical spectra of n-leg cuprate ladder systems using infrared absorption and different theoretical tools. The n-leg spin ladders interpolate between the 1D spin chain with fractional excitations and the two-dimensional Heisenberg model on the square lattice relevant for the undoped mother compounds of the high-temperature superconductors. Theoretically, we use perturbative continuous unitary transformations and quantum Monte Carlo simulations to investigate the infrared absorption of n-leg Heisenberg ladders. This joined approach of theory and experiment allows a convincing physical identification of a sharp spectral mode arising from a two-particle bound state dominating the infrared absorption at low energies. This low-energy behaviour of the infrared absorption is a generic feature being present for all studied n-leg ladder systems with $n > 1$.

TT 49.2 Fri 9:45 H 3005

Spin and lattice dynamics in the low-dimensional quantum magnet $(NO)Cu(NO_3)_3$ — Vladimir Gnezdilov[1], •Dirk Wulferding[2], Peter Lemmens[2], Yurii Pashkevich[3], Olga Volkova[4], Igor Morozov[4], and Alexander Vasiliev[4] — [1]ILTPE NAS, Ukraine — [2]IPKM, TU-BS, Braunschweig, Germany — [3]DonFTI, Donetsk, Ukraine — [4]MSU, Moscow, Russia

We present excitation spectra of $(NO)Cu(NO_3)_3$, a topological realization of the 2D Nersesyan-Tsvelik model with possible RVB or VBC ground states. The phonons display a temperature dependence and anomalies due to strong spin-lattice coupling which has not been considered in previous investigations. In addition, a broad magnetic continuum is observed and used to investigate the spin dynamics. Work supported by DFG, B-IGSM and NTH School for Contacts in Nanosystems.

TT 49.3 Fri 10:00 H 3005

The magnetic ground state of the frustrated spin chain linarite — •Britta Willenberg[1,2], Markus Schäpers[3], Kirrily Rule[1], Stefan Süllow[2], Manfred Reehuis[1], Bachir Ouladdiaf[4], Hanjo Ryll[1], Klaus Kiefer[1], and Anja Wolter[3] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Germany — [2]Institut für Physik der Kondensierten Materie, TU Braunschweig, Germany — [3]Leibniz Institute for Solid State and Materials Research IFW, Dresden, Germany — [4]Institute Laue-Langevin, Grenoble, France

The natural mineral linarite, $PbCuSO_4(OH)_2$, is found to be a frustrated one dimensional spin system. In the material CuO_4 units form chains along the b axis, in which the Cu^{2+} ions are coupled ferromagnetically to the nearest neighbor with a coupling constant $J_1 \approx 100\,\mathrm{K}$ and antiferromagnetically to the next nearest neighbor with $J_2 \approx -36\,\mathrm{K}$ leading to a ratio J_2/J_1 = -0.36. Due to a residual interchain couplings a magnetically ordered state is observed for temperatures below $T_\mathrm{N} = 2.8\,\mathrm{K}$. We will present neutron diffraction results on the magnetically ordered ground state. The propagation vector indicates an incommensurate magnetic moment structure. The refinement of the neutron diffraction data shows that the structure is formed by an elliptical helical arrangement of moments. Furthermore, we will present magnetization measurements for temperatures down to 0.25 K in applied magnetic fields along the b axis indicating a very rich magnetic phase diagram, likely as a result of magnetic frustration.

TT 49.4 Fri 10:15 H 3005

Magnetic properties and revisited exchange integrals of the frustrated chain cuprate $PbCuSO_4(OH)_2$ - linarite — •M. Schäpers[1], A. U. B. Wolter[1], F. Lipps[1], V. Kataev[1], S.-L. Drechsler[1], S. Nishimoto[1], R. Beyer[2], M. Uhlarz[2], J. Wosnitza[2], B. Willenberg[3,4], K. C. Rule[3], S. Süllow[4], and B. Büchner[1] — [1]Leibniz-Institut IFW Dresden, Dresden, Germany — [2]Dresden High Magnetic Field Laboratory, Dresden, Germany — [3]HZB für Materialien und Energie, Berlin, Germany — [4]IPKM, TU Braunschweig, Braunschweig, Germany

We present a detailed experimental and theoretical study of the frustrated s = $\frac{1}{2}$ spin-compound linarite, $PbCuSO_4(OH)_2$, with competing ferromagnetic nearest-neighbor and antiferromagnetic next-nearest-neighbor exchange interactions. Our experimental data are described using various theoretical approaches to obtain the magnetic exchange interactions. These main intrachain interactions are significantly larger as those derived previously [1, 2], causing a shift of the frustration ratio $\alpha \approx 0.36$ closer to the 1D critical point. ESR and NMR at elevated temperatures indicate a highly frustrated system with the onset of magnetic correlations far above the magnetic ordering temperature $T_N = 2.8$ K into a spin spiral ground state. Linarite shows a complex magnetic phase diagram with small saturation field, which makes it a prototype for investigating the recently predicted spin multipolar order close to the saturation field for such spin-chain compounds.

[1] M. Baran et al., Phys. Stat. Sol. (c) **3**, 220 (2006).
[2] Y. Yasui et al., JPSJ **80**, 033707 (2011).

TT 49.5 Fri 10:30 H 3005

Field-induced staggered moment stabilization in frustrated quantum magnets — •Burkhard Schmidt, Mohammad Siahatgar, and Peter Thalmeier — Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden

For low-dimensional frustrated quantum magnets, the dependence of the staggered moment on an applied magnetic field is nonmonotonic: For small and intermediate fields, quantum fluctuations are gradually suppressed, leading to an increase of the staggered moment as a function of the field strength. For large applied magnetic fields, the classically expected field dependence is recovered, namely a monotonous decrease with increasing field strength. The staggered moment is eventually suppressed when reaching the fully polarized state at the saturation field. The quantitative analysis of this behavior is an excellent tool to determine the frustration parameter of a given compound. We apply linear spin-wave theory, numerical exact diagonalization, and a self-consistent RPA theory. As an example, we discuss the recently measured field dependence of the magnetic neutron scattering intensity of $Cu(pz)_2(ClO_4)_2$ in the framework of the $S = 1/2$ two-dimensional (2D) J_1-J_2 Heisenberg model. Our results show that $Cu(pz)_2(ClO_4)_2$ is a quasi-2D antiferromagnet with intermediate frustration $J_2/J_1 = 0.2$. With this ratio, the observed reentrant behavior of the magnetic ordering temperature as a function of the applied magnetic field can be understood as a consequence of the reduced quantum fluctuations as well.

15 min. break.

TT 49.6 Fri 11:00 H 3005

Comparative study of spin orbit dominated iridates — •Mehmet Fatih Cetin[1], Peter Lemmens[1], Vladimir Gnezdilov[2], Dirk Wulferding[1], Tomohiro Takayama[3], Kei Ohashi[3], Hidenori Takagi[3,4], Kwang-Yong Choi[5], and Chengtian Lin[6] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]ILTPE NAS, Ukraine — [3]AM, Univ. Tokyo, Japan — [4]RIKEN, Japan — [5]Dept. Phys., CA Univ., Seoul, Korea — [6]MPI-FKF, Stuttgart, Germany

Raman spectroscopy is used to compare the effect of SOC on the excitation spectra in Sr_2IrO_4, $Sr_3Ir_2O_7$, and $Na_4Ir_3O_8$, which are reported to be spin liquids or anomalous Mott insulators. There is a decisive dynamics of the quasi particles and crossover phenomena related to an entanglement of electronic and lattice degrees of freedom. Work supported by DFG, B-IGSM and NTH School for Contacts in Nanosystems.

TT 49.7 Fri 11:15 H 3005

Unconventional magnetic ordering in Spin-orbit Mott insulator with Honeycomb lattice — •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_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 and study their magnetic properties [1, 2]. The temperature dependence of the susceptibility indicates a dominating antiferromagnetic exchange interaction with $\Theta_W = -116$ K and -33 K for the Na- and Ir system, respectively, while $T_N = 15$ K for both materials. Resonant X-ray scattering for the former system indicates an unconventional most likely zig-zag magnetic structure [3]. We discuss the results with respect to recent theoretical predictions for the Heisenberg-Kitaev model, including magnetic exchange beyond next-neighbor couplings and also present first results on the related Li_2RhO_3 system.

Work supported by the AvH foundation and the Erasmus Mundus EURINDIA project.

[1] Y. Singh and P. Gegenwart, Phys. Rev. B 82, 064412 (2010).
[2] Y. Singh, S. Manni, P. Gegenwart, arXiv:1106.0429.
[3] X. Liu et al., Phys. Rev. B 83, 220403(R) (2011).

TT 49.8 Fri 11:30 H 3005

THz and infrared excitation spectrum below the Jahn-Teller transition in $Sr_3Cr_2O_8$ — •Zhe Wang[1], Michael Schmidt[1], Axel Günther[1], Franz Mayr[1], Diana Quintero-Castro[2,3], A. T. M. Nazmul Islam[2], Bella Lake[2,3], Hans-Albrecht Krug von Nidda[1], Alois Loidl[1], and Joachim Deisenhofer[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, D-14109 Berlin, Germany — [3]Institut für Festkörperphysik, Technische Universität Berlin, D-10623 Berlin, Germany

We report on optical excitations observed recently in $Sr_3Cr_2O_8$ by THz and infrared spectroscopy. Low-energy excitations below 3 THz are detected by THz time domain spectroscopy. These excitations can be divided into two different classes according to the temperature-dependent properties. One is emergent right below the Jahn-Teller transition temperature, which is determined by specific heat measurement to occur at 285 K [1,2]. The other appears only below 100 K, where the fluctuations are sufficiently suppressed, consistent with the temperature dependence of low-energy Raman modes [3]. Infrared transmission measurements reveal a broad crystal-field excitation, which can be associated with an electronic transition from E to T_2 orbital states.

[1] Zhe Wang et al., Phys. Rev. B 83, 201102 (2011)
[2] D. L. Quintero-Castro et al., Phys. Rev. B 81, 014415 (2010)
[3] D. Wulferding et al., Phys. Rev. B 84, 064419 (2011)

TT 49.9 Fri 11:45 H 3005

Optical spectroscopy of the Triangular Lattice Antiferromagnets $CuCrO_2$ and α-$CaCr_2O_4$ — •Michael Schmidt[1], Zhe Wang[1], Franz Mayr[1], Sandor Toth[2,3], Bella Lake[2,3], Nazmul Islam[2], Vladimir Tsurkan[1], Alois Loidl[1], and Joachim Deisenhofer[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany — [2]Helmholtz Zentrum Berlin, Berlin 14109, Germany — [3]Institut für Festkörperphysik, Technische Universität Berlin, D-10623 Berlin, Germany

We will compare and discuss our results obtained by optical spectroscopy on $CuCrO_2$ and α-$CaCr_2O_4$. While $CuCrO_2$ is famous for its multiferroicity [1], in α-$CaCr_2O_4$ a polarization can only be observed under the application of electric or magnetic field, despite having a closely related structure [2]. At near infrared and visible light frequencies we observe Cr^{3+} crystal field absorptions and below T_N excitons and exciton-magnon-transitions appear. The width of these exciton-magnon transitions is analyzed with respect to the existence of Z_2 vortices as proposed by Kojima et al. [3].

[1] S. Seki et al., Phys. Rev. Lett. 101, 067240 (2008)
[2] K. Singh et al., Phys. Rev. B 84, 064129 (2011)
[3] N. Kojima et al., J. Phys. Soc. Jpn. 62, 4137 (1993)