TT 2: Symposium: High Magnetic Field Phenomena in Low Dimensional Magnets

Time: Monday 9:30–13:00 Location: H 0104

TT 2.1 Mon 9:30 H 0104

High magnetic fields with low dimensional magnets — •Alan Tennant — Hahn Meitner Institut, Berlin, Germany

High magnetic fields provide a near perfect degree of control over the physics of low dimensional magnets. A broad array of new physical states and phase transitions are being predicted theoretically and discovered experimentally. In this talk I give an overview of some of the new magnetic states that are being discovered including quantum criticality, exotic phase transitions, and fractionalisation of quasi-particles. I shall also outline some of the challenges for the future for experiment and the developing array of tools and materials that are opening up this field of study.

Invited Talk TT 2.2 Mon 10:00 H 0104

High Field NMR in Low Dimensional Quantum Antiferromagnets — •Claude Berthier[1], Hadrien Mayaffre[2], Martin Klanjšek[1], Steffen Krämer[1], and Mladen Horvatić[1] — [1]Grenoble High Magnetic Field Laboratory (GHMFL), CNRS, BP — [2]Lab. de Spectrométrie Physique, UJF Grenoble I

We present high field NMR studies of the field induced magnetic ordering in a few quasi-1D quantum antiferromagnets. $Cu_2(C_5H_{12}N_2)_2Cl_4$ (Cu(Hp)Cl) has for long been considered as the archetype of a strong coupling spin-ladder system. We show that it can be well understood in the framework of a spin-ladder with a staggered Dzyaloshinskii-Moriya (DM) interaction on the rungs [1]. $CuBr_4(C_5H_{12}N)_2$ (BPCB) is made of regular spin-ladders (without DM interaction) weakly coupled together. Its phase diagram between the two quantum critical field H_{c1} and H_{c2} is fully dominated by the H dependence of the Luttinger liquid parameters of the ladders [2]. We also briefly report the NMR evidence for the existence of an unconventional quantum ground state in the 1/3 magnetization plateau in the frustrated diamond chain compound $Cu_3(CO_3)_2(OH)_2$ (azurite) [3].

[1] M. Clémancey *et al.*, Phys. Rev. Lett. **97**, 167204 (2006).
[2] M. Klanjšek, H. Mayaffre, *et al.*, unpublished.
[3] S. Krämer *et al.*, unpublished.

TT 2.3 Mon 10:30 H 0104

Exotic ground states in high magnetic fields — •Andreas Läuchli — IRRMA, Ecole Polytechnique Fédérale de Lausanne, Switzerland

Over the last few years it has been discovered that quantum magnets in strong magnetic fields can host a variety of long-sought exotic phases. In this talk we review recent theoretical efforts revealing magnetization plateaux with complex structures, supersolid phases sustaining simultaneous longitudinal and transverse magnetic order, as well as spin nematic phases, which spontaneously break spin rotational symmetry in the absence of an ordered moment. We discuss the experimental signatures of these phases and point out materials which could possibly display such exciting behavior.

TT 2.4 Mon 11:00 H 0104

High-field properties of a critical frustrated chain cuprate: Li_2ZrCuO_4 — •Stefan-Ludwig Drechsler[1], Rüdiger Klingeler[1], Natalia Tristan[1], Norman Leps[1], Johannes Richter[2], Thomas Lorenz[3], Olga Volkova[4], Alexander Vasiliev[5], and Bernd Büchner[1] — [1]IFW-Dresden, P.O. Box 270116, D-01171 Dresden, — [2]Inst. f. Theoret. Physik, Universität Magdeburg — [3]II. Physikal. Inst., Universität zu Köln — [4]Inst. f. Electronics and Automatics, Moscow, Russia — [5]Lomonosov University, Moscow, Russia

We report an unusual strong field dependence of the magnetic specific heat $c_p(T,H)$, the thermal expansion $\alpha(T,H)$, and the magnetization $m(T,H)$ curve of the frustrated edge-shared chain cuprate Li_2ZrCuO_4 which is close to the quantum critical point between ferromagnetic and helical ordering [1]. The low-temperature peak of $c_p(T)$ is first down shifted for $H < 9$ T, then reaches a broad plateau before its position is up shifted at high fields $H \approx 30$ T. The thermal expansion α changes its sign at about 9 T. The magnetization $m(H)$ saturates at 15-20 T at low temperature well above the estimated saturation field $H_s \approx 4.5$ T for the 1D J_1-J_2–Heisenberg model pointing to a non-neglible influence of the interchain exchange in accord with estimates based on the dispersion of the LDA bands perpendicular to the chain direction. Possible scenarios for the deviation of the experimental $c_p(T,H)$ data at high fields from the predictions of the isotropic 1D J_1-J_2-Heisenberg model are briefly discussed.

[1] S.-L. Drechsler *et al.*, Phys. Rev. Lett. **98**, 077202 (2007).

15 min. break

Invited Talk TT 2.5 Mon 11:30 H 0104

Dimensional Reduction at a Quantum Critical Point — •Cristian Batista — Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA

Competition between ground states near a quantum critical point is expected to lead to unconventional behavior in low dimensional systems. New phases of matter have been predicted, and explanations proposed for unsolved problems including non-Fermi liquid behavior and high temperature superconductivity using two-dimensional (2d) theories. In this talk, I will present a theory that describes the Bose-Einstein condensate (BEC) quantum critical point (QCP) in layered systems with a frustrated inter-layer coupling. I will demonstrate that the main effect of this geometric frustration is to reduce the dimensionality of the QCP (its critical exponents are the ones expected for a 2d system). In addition, I will present the first experimental evidence of dimensional reduction at a QCP observed in the Mott insulator $BaCuSi_2O_6$ (Han Purple).

TT 2.6 Mon 12:00 H 0104

Excitation hierarchy of the spin-1 large-D system $NiCl_2$-$4SC(NH_2)_2$ — •S.A. Zvyagin[1], J. Wosnitza[1], C.D. Batista[2], J. Krzystek[3], V.S. Zapf[4], M. Jaime[4], A. Paduan-Filho[5], M. Tsukamoto[6], and N. Kawashima[6] — [1]Hochfeld-Magnetlabor Dresden/Forschungszentrum Dresden - Rossendorf — [2]LANL, USA — [3]NHMFL, USA — [4]NHMFL/LANL, USA — [5]Sao Paulo University, Brzail — [6]ISSP, University of Tokyo, Japan

$NiCl_2$-$4SC(NH_2)_2$ (known as DTN) is an $S = 1$ chain system with the easy-plane anisotropy dominating over the exchange interaction (so-called large-D system) and a new candidate for studying the field-induced Bose-Einstein condensation of magnons. The excitation spectrum of DTN has been investigated by means of tunable-frequency ESR technique in fields up to 25 T. Based on analysis of the magnon excitation spectrum, a revised set of spin-Hamiltonian parameters was obtained. These values were used to calculate the AFM phase boundary, low-temperature magnetization and the frequency-field dependence of two-magnon bound-state excitations, predicted by theory and observed in DTN for the first time. Excellent quantitative agreement with experimental data was obtained.

[1] Phys. Rev. Lett. 98, 047205 (2007).

TT 2.7 Mon 12:15 H 0104

Exploring field-induced quantum phase transitions in molecule-based magnets — •Michael Lang[1], Katarina Removic-Langer[1], Yeekin Tsui[1], Ulrich Tutsch[1], Bernd Wolf[1], Andrei Prokofiev[1], Wolf Assmus[1], Roser Valenti[2], Andreas Honecker[3], Matthias Wagner[4], and Stefan Wessel[5] — [1]Phys. Inst. Univ. Frankfurt, SFB/TR 49 — [2]Inst. f. Theor. Physik, Univ. Frankfurt, SFB/TR 49 — [3]Inst. f. Theor. Physik, Univ. Göttingen — [4]Inst. f. Anorg. u. Analyt. Chemie, Univ. Frankfurt, SFB/TR 49 — [5]Inst. f. Theor. Physik III, Univ. Stuttgart

Molecule-based quantum magnets offer exciting new possibilities for exploring quantum many-body effects under variable and well-controlled conditions. Subjects of high current interest are the unusual magnetothermal effects close to a magnetic field-induced quantum critical point and the possibility to realize a Bose-Einstein condensation (BEC) of magnetic excitations. We focus here on Cu(II)-containing coordination polymers, which represent model systems with energy scales small enough for laboratory fields to tune the system close to their quantum critical points. We will discuss the magnetocaloric effect close to the saturation field of a uniform S = 1/2 antiferromagnetic Heisenberg chain and the field-induced BEC of magnetic excitations in a quasi-twodimensional coupled-dimer system.

TT 2.8 Mon 12:45 H 0104

Diverging low-temperature thermal expansion of the spin-

ladder system $(C_5H_{12}N)_2CuBr_4$ — •Thomas Lorenz[1], Oliver Heyer[1], Markus Garst[2], Fabrizio Anfuso[2], Achim Rosch[2], Christian Rüegg[3], and Karl Krämer[4] — [1]Institue of Physics II, University of Cologne, Germany — [2]Institue of Theoretical Physics, University of Cologne, Germany — [3]Centre for Nanotechnology and Dep. of Phys. and Astronomy, University College London, UK — [4]Department of Chemistry and Biochemistry, University of Bern, Switzerland

The magnetic subsystem of piperidinium copper bromide $(C_5H_{12}N)_2CuBr_4$ represents a model system of an experimental realization of a two-leg spin-ladder Hamiltonian. Due to comparatively weak antiferromagnetic exchange couplings along the legs ($\simeq$ 12.9 K) and the rungs ($\simeq$ 3.6 K) of the ladders, two quantum phase transition are easily accessible in this compound: at $H_{c1} \simeq 6.8$ T the gap closes and at $H_{c2} \simeq 13.9$ T the field-polarized ferromagnetic state is reached. We present high-resolution measurements of the uniaxial thermal expansion and magnetostriction of $(C_5H_{12}N)_2CuBr_4$. For both quantities we observe pronounced anomalies arising from the pressure dependencies of the critical fields. The thermal expansion shows a very complex behavior with various sign changes and approaches a $1/\sqrt{T}$ divergence at the critical fields. All these low-temperature features are semi-quantitatively explained within a free fermion model; full quantitative agreement is obtained with Quantum Monte Carlo simulations.

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