MA 44: PhD Symposium Quantum Magnets (contributed talks)

Time: Wednesday 15:00–17:30 Location: HSZ 403

MA 44.1 Wed 15:00 HSZ 403

Evolution of antiferromagnetic domains in the all-in-all-out ordered pyrochlore $Nd_2Zr_2O_7$ — •L. Opherden[1,2], J. Hornung[1,2], T. Herrmannsdörfer[1], J. Xu[3,4], A. T. M. N. Islam[3], B. Lake[3,4], and J. Wosnitza[1,2] — [1]Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany — [2]Institut für Festkörperphysik, TU Dresden, Germany — [3]Abteilung Quantenphänomene in neuen Materialien, HZB, Berlin, Germany — [4]Institut für Festkörperphysik, TU Berlin, Germany

We report the observation of magnetic domains in an exotic, antiferromagnetically ordered all-in-all-out state of $Nd_2Zr_2O_7$, induced by spin canting. Two different spin arrangements fulfill this configuration of Ising-like spins. This leads to the occurrence of magnetic domains. While the two all-in-all-out spin arrangements occur equiprobable in zero field, the application of a magnetic field along the [111] direction allows for a change of their domain structure. We have investigated $Nd_2Zr_2O_7$ by means of static magnetization and dynamic susceptibility. The ground state occurs below 0.31 K and is stable for external magnetic fields up to 0.14 T. The magnetic domains are observed through a hysteresis of the susceptibility $\chi_{ac}(H)$. No hysteresis occurs in case the external magnetic field is applied along [100].

MA 44.2 Wed 15:15 HSZ 403

Quasi-toroidal poling of a nanomagnetic lattice — •Jannis Lehmann[1], Claire Donnelly[1,2], Peter Derlet[2], Laura Heyderman[1,2], and Manfred Fiebig[1] — [1]Department of Materials, ETH Zurich, Switzerland — [2]Paul Scherrer Institute, Villigen PSI, Switzerland

Two-dimensional dipolar coupled magnetic nanostructures can be seen as model spin systems to investigate phenomena such as spontaneous order or magnetic frustration. It is thus possible to model specific types of ferroic order artificially by implementing design elements at the mesoscale. In a suitably engineered unit cell it is possible to achieve uniform spin-ordering in the form of magnetic whirls defining a net toroidal moment. Considering the lattice as a whole, the system can then form energetically degenerate toroidal domains in its ground state with opposite chirality. Our unit cell consists of four lithographically patterned sub-micrometer permalloy bars that are arranged on a silicon substrate forming the edges of a square. We present a strongly coupled nanomagnetic lattice that forms toroidal domains in its as-grown state. A saturated magnetized non-toroidal state can then be switched to a toroidal state by using the stray field of a magnetic tip in a scanning probe microscope. We interpret the poling procedure in terms of application of an effective toroidal field and present the possibility to write domains of defined handedness. As a first quasi-toroidal poling process in an artificial lattice, this work is an important step towards accessing the physics of ferrotoroidicity as a new type of ferroic order at mesoscopic length scales.

MA 44.3 Wed 15:30 HSZ 403

Minimal model for the frustrated spin ladder system $BiCu_2PO_6$ — •Leanna Splinter[1], Nils Alexander Drescher[2], Holger Krull[3], and Götz Silvester Uhrig[4] — [1]tu Dortmund — [2]tu Dortmund — [3]tu Dortmund — [4]tu Dortmund

The microscopic model of the compound $BiCu_2PO_6$ contains tubelike structures, which can be described by coupled frustrated spin ladders with a finite gap. Inelastic neutron scattering experiments showed that the triplon excitation modes are split and not three-fold degenerate, as would be expected for spin isotropy. Because of the large atomic number of the bismuth ions (Z=83) the spin-orbit-coupling has a non-negligible effect by the Dzyaloshinskii-Moriya interaction on the dispersion. Using a deepCUT approach for the isotropic model and including the anisotropic interactions on a mean-field level we are able to describe the low-energy part of the dispersions by Dzyaloshinskii-Moriya interactions of about 30 % [1]. Additionally, we can reproduce the magnetic field dependence. Currently, we are extending our model from the one-particle level to including quasi-particle decay, which is induced by the anisotropic interactions. The hydridization between one- and two-triplon states is claimed to explain the different bending behaviour of the individual triplon dispersions [2].

[1] L. Splinter *et al.*, Phys. Rev. B 94, 155115 (2016).
[2] K. W. Plumb *et al.*, Nat. Phys. 12, 224 (2015).

MA 44.4 Wed 15:45 HSZ 403

Magnetic correlations in artificial xy spin systems — •Naëmi Leo[1], Oles Sendetskyi[1], Dominik Schildknecht[1], Peter Derlet[1], Stefan Holenstein[1], Hubertus Luetkens[1], Stephen Lee[2], and Laura J. Heyderman[1] — [1]Paul Scherrer Institute, Villigen, Switzerland — [2]St. Andrews University, St. Andrews, Scotland

The coupling of continuous spin degrees of freedom on two-dimensional lattices can give rise to interesting phenomena such as the topological Kosterlitz-Thouless transition. A model system to study the influence of external parameters on the magnetic order can be emulated by controlled arrangements of nanomagnets coupled via dipolar interactions. Using electron beam lithography periodic arrangements of circular dots with diameters in the order of a few tens of nanometers can be patterned. Due to the circular shape of the magnetic dots, the resulting macrospin resembles a freely-rotating in-plane xy moment.

Here, we investigate the thermal behaviour and onset of magnetic correlations of fluctuating, interacting xy moments on a square lattice using low-energy muon spin relaxation (muSR), which is a highly sensitive probe for magnetic fields and fluctuations. While the magnetic dynamics of non-interacting xy moments are described by one time scale determined by the superparamagnetic blocking, strongly interacting macrospins develop partial static order at temperatures where non-interacting single particles still fluctuate. In this regime, the dynamics are described by two time scales related to the strong correlations due to a cooperative phase transition.

MA 44.5 Wed 16:00 HSZ 403

Evidence for possible quantum spin-ice behaviour in Pr2Hf2O7 as seen by inelastic neutron scattering. — •Alexandros Samartzis[1], Vivek K. Anand[1], Nazmul A.T.M. Islam[1], Andrew Wildes[2], Robert Bewley[3], Andrey A. Podlesnyak[4], David Voneshen[3], and Bella Lake[1] — [1]Helmholtz-Zentrum Berlin, Germany — [2]Institute Laue-Langevin, France — [3]Rutherford Appleton Lab, UK — [4]Oak Ridge, National Lab, US

The rare earth pyrochlore systems are well known for their diverse magnetic ground state due to quintenssential lattice for frustration and Ising anisotropy. A delicate competition of crystal field, exchange and dipolar interactions can lead to exotic magnetic ground states, such as spin-ice. Pr-based pyrochlores are candidates of a new ground state named, quantum spin-ice, due to low magnetic moment of the non-Kramers Pr3+ ion. Recently, the low temperature macroscopic measurements of Pr2Hf2O7 as well as inelastic neutron scattering (INS) of powder sample have shown evidence for the realization of quantum spin-ice behavior (i.e. quantum fluctuations and slow spin-dynamics in the ground state etc). Motivated by the above interesting results, we extended the study using polarised and low energy neutron scattering with and without external field on a PHO single crystal, grown by the floating zone technique. The first results reveal the absence of any transition down to 85mK. Broad diffuse scattering and pinch points indicate increased quantum fluctuations. Inelastic data reveal a broad dispersionless magnetic excitation, with a narrow band gap which shifts to higher transferred energies by an applied field.

15 min. break.

MA 44.6 Wed 16:30 HSZ 403

Pseudo-Goldstone magnons in the Heisenberg helimagnet $ZnCr_2Se_4$. — •Yuliia Tymoshenko[1], Yevhen Onykiienko[1], Pavlo Portnichenko[1], Alistair Cameron[1], Doug Abernathy[2], Jacques Ollivier[3], Astrid Schneidewind[4], Vladimir Tsurkan[5], and Dmytro Inosov[1] — [1]TU Dresden, D-01069 Dresden, Germany — [2]ORNL, Oak Ridge, Tennessee 37831, USA — [3]ILL, 38042 Grenoble, France — [4]JCNS, D-85747 Garching, Germany — [5]University of Augsburg, 86135 Augsburg, Germany

Chromium spinels provide great opportunities to investigate magnetic interactions between classical spins on the almost ideal pyrochlore lattice. $ZnCr_2Se_4$ is a spinel compound with incommensurate spin-spiral ground state. In this talk we present inelastic neutron scattering measurements of magnetic excitations in $ZnCr_2Se_4$ over a wide range of energies in the whole Brillouin zone. Comparing our data with spin-dynamical calculations we have extracted exchange parameters up to the fourth nearest neighbour and found a good agreement

with the isotropic Heisenberg model. Furthermore, measurements of low-energy helimagnon excitations performed in the single-domain spin spiral state revealed two distinct modes: the Goldstone mode emerging from incommensurate magnetic Bragg peaks and a soft pseudo-Goldstone mode emanating from an orthogonal wave vector.

MA 44.7 Wed 16:45 HSZ 403

Designing Kitaev spin liquids in metal-organic frameworks — •Masahiko G. Yamada, Hiroyuki Fujita, and Masaki Oshikawa — Institute for Solid State Physics, University of Tokyo, Kashiwa 277-8581, Japan

Kitaev's honeycomb lattice spin model is a remarkable exactly solvable model, which has a particular type of spin liquid as the ground state, which we call Kitaev spin liquid. Although its possible realization in iridates and α-$RuCl_3$ has been vigorously discussed recently, these materials have substantial non-Kitaev direct exchange interactions and do not show a spin liquid ground state. We theoretically propose new metal-organic frameworks (MOFs) with Ru^{3+} (or Os^{3+}) forming the honeycomb lattice as promising candidates for a more ideal realization of Kitaev-type spin models where the direct exchange interaction is strongly suppressed. The great flexibility of MOFs allows generalization to other three-dimensional lattices, for potential realization of a variety of spin liquids, including Weyl spin liquids. We argue that, in this class of materials, the degeneracy of the highest occupied molecular orbitals of the organic ligand implies a suppression of non-Kitaev interactions. As concrete examples, we estimate interactions in MOFs with oxalate-based (or tetraaminopyrazine-based) ligands, and show that they are promising candidates to realize Kitaev spin liquids.

MA 44.8 Wed 17:00 HSZ 403

Spectroscopic investigation of a spin liquid (RVB) state and local distortions in the frustrated spin-1/2 Copper Carbodiimide (CuNCN) — Azat Sharafeev[1], Vladimir Gnezdilov[2], •Peter Lemmens[1], Xiaohui Liu[3], Andrei Tchougreeff[3], and Richard Dronskowski[3] — [1]TU-BS, Braunschweig — [2]ILTP, Kharkov — [3]RWTH Aachen

In CuNCN there exist corrugated layers of Cu2+ bridged by NCN2-groups with a square planar Cu2+ coordination. Based on very large AF exchange and frustration a nonmagnetic ground state is observed. On the other side, some evidence for hidden magnetic order with strong fluctuations typical for low dimensionality has been given. We critically discuss the presently known scenarios on the basis of Raman scattering data, giving evidence for local lattice distortions for T<60K as well as high energy excitations. Work supported by RTG-DFG 1952/1, the Laboratory for Emerging Nanometrology, TU Braunschweig, and NTH Contacs in Nanosystems.

MA 44.9 Wed 17:15 HSZ 403

Comparison between dynamical permeability and permittivity in $Dy_2Ti_2O_7$ at low temperatures — •Steffen Harms[1], Christoph P. Grams[1], Martin Valldor[2], Johanna Frielingsdorf[1], Thomas Lorenz[1], and Joachim Hemberger[1] — [1]Institute of Physics II, University of Cologne, Germany — [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

$Dy_2Ti_2O_7$ is one of the well known spin-ice compounds in which magnetic monopoles are emergent [1]. These monopoles carry electric dipoles [2] and therefore their dynamics is apparent in the dielectrical response $\varepsilon^*(\nu)$. Recently published data reveal the speeding up of a dielectric relaxation process reaching a relaxation rate of up to $\nu \sim$ 100 kHz near the critical endpoint of the (H,T)-phase diagram [3]. This process can be associated with the hopping of magnetic monopoles and should, among other contributions, leave a fingerprint in the magnetic ac-permeability. Here we present a comparative broadband study of complex permittivity and permeability in the mK range in order to disentangle the different contributions to the dynamic response in the spin ice $Dy_2Ti_2O_7$.

Funded through the Institutional Strategy of the University of Cologne within the German Excellence Initiative and the Deutsche Forschungsgemeinschaft through project HE-3129/2-1 and CRC 1238.

[1] C. Castelnovo et al., Nature 451, 42 (2008).
[2] D. I. Khomskii, Nature Communications 3, 1 (2012).
[3] C. P. Grams et al., Nature Communications 5, 4853 (2014).