MA 5: Spin Textures and magnetic Phase Transitions

Time: Monday 9:30–13:30 Location: H34

Invited Talk MA 5.1 Mon 9:30 H34

Néel-type skyrmions in a type-I multiferroic compound — •Istvan Kezsmarki[1], Sandor Bordacs[1], Peter Milde[2], Jonathan White[3], Vladimir Tsurkan[4], and Alois Loidl[4] — [1]Department of Physics, Budapest University of Technology and Economics, Budapest, Hungary — [2]Institut für Angewandte Photophysik, TU Dresden, Dresden, Germany — [3]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Villigen, Switzerland — [4]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, Augsburg, Germany

GaV4S8, a member of the lacunar spinel family, is the first known example of skyrmion-host materials with non-chiral but polar crystal structure. This compound is a magnetic semiconductor with a rhombohedral crystal symmetry (R3m) and an easy-axis magnetic anisotropy. In this compound we observed the formation of a Néel-type skyrmion lattice, which exists over a broad temperature range [1]. This is in contrast to Bloch-type skyrmions found in chiral magnets, which are stabilized by thermal fluctuations in small pockets of the phase diagram. We found that the orientation of these Néel-type skyrmions is not controlled by the external magnetic field, but instead confined to the magnetic easy axis. Due to the polar nature of the host crystal, these magnetic skyrmions wear a ferroelectric dressing and exhibit strong static and dynamic magnetoelectric effects [2,3].

[1] I. Kézsmárki et al., Nat. Mater. 14, 1116 (2015) [2] E. Ruff et al., Sci. Advances 1, e1500916 (2015) [3] Z. Wang et al., Phys. Rev. Lett. 115, 207601 (2015)

15 min. break

MA 5.2 Mon 10:15 H34

Four-ion magnetic coupling in the heavy rare earth elements — •Eduardo Mendive Tapia and Julie Staunton — Department of Physics, University of Warwick, Coventry CV4 7AL, U.K.

The study of the magnetic properties of the heavy rare earth elements has attracted much attention owing to the complexity of their magnetic order. A complex series of magnetic phases, spanning antiferromagnetic (AF) helical, conical helical and fan phases and also ferromagnetic states is formed as the temperature and applied magnetic field are varied. The AF phases are usually incommensurate with the underlying hexagonal close packed lattice. The origin of these magnetic structures derives from the indirect interaction of the local moments, formed from localized 4f states, which is mediated by the conduction electrons. Here we employ an ab-initio Disordered Local Moment (DLM) theory to investigate the magnetic phase transitions. The orientations of thermally fluctuating 'local moments' associated with the 4f electrons are considered to vary slowly on the scale of the faster itinerant conduction electronic motions which in turn drive the indirect interactions between the local moments. We focus on the study of transitions that are characteristic of the common valence electronic structure among the heavy rare earth elements. As a main result, we identify an isotropic four-ion magnetic coupling, emerging from the nature of the conduction electronic structure, as the decisive driving factor for the temperature and field evolution of the magnetic ordering.

MA 5.3 Mon 10:30 H34

Skyrmionic phases and skyrmion lifetime in an ultrathin magnetic film — Levente Rózsa[1,2], Eszter Simon[1], Krisztián Palotás[1], László Udvardi[1], and •László Szunyogh[1] — [1]Budapest University of Technology and Economics, Budapest, Hungary — [2]Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest, Hungary

In ultrathin magnetic films, the Dzyaloshinsky-Moriya interaction (DMI) between local magnetic moments can lead to the formation of chiral spin structures like spin-spirals and magnetic skyrmions. Particularly interesting are magnetic phase transitions influenced by DMI. In this work we determined the magnetic B-T phase diagram of PdFe bilayer on Ir(111) surface by performing Monte Carlo and spin dynamics simulations based on an effective classical spin model. The parameters of the spin model were determined by ab initio methods. At low temperatures we found three types of ordered phases, while at higher temperatures, below the completely disordered paramagnetic phase, a large region of the phase diagram is associated with a fluctuation-disordered phase. Within the applied model, this state is characterized by the presence of skyrmions with finite lifetime. According to the simulations, this lifetime follows the Arrhenius law as a function of temperature [1].

[1] L. Rózsa, E. Simon, K. Palotás, L. Udvardi, L. Szunyogh arXiv:1510.04812 (2015)

MA 5.4 Mon 10:45 H34

Optically probing symmetry breaking in the Skyrmion cuprate Cu_2OSeO_3 — •Rolf B. Versteeg[1], Ignacio Vergara[1], Simon Schäfer[1], Dario Bischoff[1], Aisha Aqeel[2], Thomas T.M. Palstra[2], Markus Grüninger[1], and Paul H.M. van Loosdrecht[1] — [1]II. Physikalisches Institut - Universität zu Köln, Zülpicher Straße 77, 50937 Cologne, Germany — [2]Zernike Institute, Nijenborgh 4, 9747AG Groningen, The Netherlands

Cubic chiral crystal structures provide an ideal platform for the creation and manipulation of topologically protected spin-vortex structures known as Skyrmions. In these materials, the absence of inversion symmetry, the chiral crystal structure, different types of magnetic order, and their coupling to one another give rise to a multitude of linear optical phenomena. These can be used in all-optical methods to access the various magnetic phases as well as the Skyrmion dynamics.

Here, we present a study of the optical properties of the Skyrmion cuprate Cu_2OSeO_3. Through ellipsometry, we show the existence of dipole-active local crystal-field excitations. Spectroscopic polarimetry is further used to study the different sources of optical rotation present in Cu_2OSeO_3. The natural optical rotation, originating in the chiral crystal structure, shows the presence of a zero-field magnetoelectric coupling. The magneto-optical activity, quantified by a Verdet coefficient as large as $V=-35\cdot 10^3$ rad/T·m, allows us to map the magnetic phase diagram, including the Skyrmion lattice phase. Our results show that optical detection of the Skyrmion phase in Cu_2OSeO_3 is possible and opens new paths in probing of magnetic topological matter.

MA 5.5 Mon 11:00 H34

Influence of lattice strain on the formation of magnetic skyrmions — •Julian Hagemeister, Elena Vedmedenko, and Roland Wiesendanger — University of Hamburg, Jungiusstrasse 11, D-20355 Hamburg, Germany

The properties of magnetic skyrmions have both experimentally and theoretically mainly been investigated in the context of materials providing an isotropic environment up to now. There are only few publications that deal with the influence of anisotropic environments among which is the recent report about the observation of deformed skyrmions in chiral magnets with crystal strain [1]. However, the strain is often inevitable even in epitaxially grown magnetic films. Here, the influence of spatially varying strain on the magnetic structure of spin spirals and skyrmions is studied. It is shown that a distortion of the atomic structure leading to changes in the exchange tensor results in periodic deformation of non-collinear magnetic structures. Particularly, we find that the wave vector of magnetic spirals is directly related to the periodicity of the spatial variation of the exchange interaction. This effect can induce a zigzag shape of the wave fronts as well as anisotropic skyrmion lattices, when an external magnetic field is applied. The results can be used to engineer skyrmion tracks similar to the ones proposed recently [2].

[1] K. Shibata, et al. Large anisotropic deformation of skyrmions in strained crystal Nat. Nanotechnol. 10, 589-592 (2015).

[2] Fert, A., Cros, V. & Sampaio, J. Skyrmions on the track. Nat. Nanotechnol. 8, 152-156 (2013).

MA 5.6 Mon 11:15 H34

Ultrafast cooling and heating mechanisms of the laser induced phase transition in CuO — •Johan Hellsvik[1], Johan H. Mentink[2], and José Lorenzana[3] — [1]KTH, Stockholm, Sweden — [2]Radboud University Nijmegen, The Netherlands — [3]ISC-CNR, Rome, Italy

We report theoretical modeling of the sub-picosecond magnetic phase transition [1] which recently has been experimentally observed in optically pumped samples of multiferroic CuO [2]. Using atomistic spin dynamics simulations we observe that independently of the excitation mechanism, the phase transition from collinear to spin-spiral order can proceed in exchange interaction driven dynamics on picosecond time scales. Intriguingly, different excitation mechanisms are found to drive distinct dynamics, in which the spin system either cools down or heats up on sub picosecond time scales [3].

[1] Johnson et al., Phys. Rev. Lett. 108, 037203 (2012) [2] Kimura et al., Nat. Mater. 7, 291 (2008) [3] Hellsvik et al., arXiv:1509.03202

MA 5.7 Mon 11:30 H34

Tunable magnetic phase transitions in ultrathin films — Levente Rózsa[1,2], László Udvardi[1], •László Szunyogh[1], and István A. Szabó[3] — [1]Budapest University of Technology and Economics, Budapest, Hungary — [2]Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest, Hungary — [3]University of Debrecen, Debrecen, Hungary

The Dzyaloshinsky-Moriya interaction (DMI) between local magnetic moments has a great impact in spintronics applications. In this contribution we present theoretical investigations of the magnetic properties of an Fe monolayer on W and Ta (110) surfaces. We found different types of ground states as a function of the inward relaxation of the Fe layer varied between 10% and 17% with respect to the ideal layer spacing of the substrate. In case of W(110) substrate this is reflected in a reorientation of the easy axis from in-plane to out-of-plane. For Ta(110) a switching appears from the ferromagnetic state to a cycloidal spin spiral state, then to another spin spiral state with larger wave vector and, for even larger relaxations, a rotation of the normal vector of the spin spiral is found. Classical Monte Carlo simulations indicate temperature-induced transitions between the different magnetic phases observed in the Fe/Ta(110) system. Moreover, we use finite-temperature spin wave theory to explain and analyze these phase transitions qualitatively and quantitatively [1].

[1] L. Rózsa, L. Udvardi, L. Szunyogh, I. A. Szabó, Phys. Rev. B 91, 144424 (2015)

15 min break

MA 5.8 Mon 12:00 H34

Emergent Phases in quantum magnets — •Markos Skoulatos[1], Christian Pfleiderer[1], and Astrid Schneidewind[2] — [1]Physik-Department, Technische Universitaet Muenchen, D-85748 Garching, Germany — [2]Juelich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Juelich GmbH, Garching, Germany

Quantum magnets exhibit exotic ground states and novel elementary excitations, complex correlations and generic quantum critical points. Phenomena like frustration, condensation and quantum disorder are at the very heart of this field. More interestingly, novel emergent behavior can arise as a result of interplay between different characters of the same system. Examples include spin and orbital interplay in Mott insulators or spin liquid and spin nematic phases arising due to frustration in very simple model systems. In the light of this, some new results will be briefly discussed.

MA 5.9 Mon 12:15 H34

Magnetic order via long ranged RKKY interaction in frustrated pyrochlore magnets — •Sebastian Paeckel[1] and Paul McClarty[2] — [1]Georg-August Universität - Institut für Theoretische Physik, Göttingen — [2]Wandham college, University of Oxford

Recent experiments on Pr2Ir2O7, which is poised close to a metal-insulator transition, revealed confusing low-temperature behaviour e.g. a large anomalous hall effect accompanied with an unmeasurable small magnetization at $T < 1$K with no sign of long ranged magnetic order which led some authors to suggest Pr2Ir2O7 as a candidate for a metallic spin liquid[1,2]. Remarkably Pr2Ir2O7 is the only compound in the pyrochlore iridate series which exhibits metallic behaviour naturally leading to the question on how the itinerant character of the 5d Ir system influences the ordering behaviour of the geometrically frustrated localised Pr moments.

In my talk I'm going to present results of calculations of the magnetic phase diagram for a simplified model capturing the interplay between classical localised magnetic moments and itinerant S=1/2 fermions with both constituents placed on a pyrochlore lattice. Taking into consideration the full long ranged character of the induced RKKY interaction then permits to relate the emerging magnetic structures to the frustrated nature of the itinerant electronic system.

[1] S. Nakatsuji, Y. Machida, J. J. Ishikawa, S. Onoda & Y. Karaki, Journal of Physics: Conference Series 320 (2011) 012056

[2] S. Nakatsuji, Y. Machida, Y. Maeno, T. Tayama et al., PRL 96, 087204 (2006)

MA 5.10 Mon 12:30 H34

Zero-field μSR and HF-EPR study on complex magnetic order in layered trigonal $MnSb_2O_6$ — •Changhyun Koo[1], Rajib Sarkar[2], Michael Tzschoppe[1], Johannes Werner[1], Elena A. Zvereva[3], Hans-Henning Klauss[2], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute of Physics, Heidelberg University, Germany — [2]Institute for Solid State Physics, TU Dresden, Germany — [3]Faculty of Physics, Moscow State University, Russia

A new phase of $MnSb_2O_6$ (P-31m) is studied by static and dynamic magnetic probes. SQUID data imply AFM order below $T_N = 8.5$ K and a spin-flop transition at $B_{SF} \leq 1$ T. Antiferromagnetic resonance (AFMR) modes observed by means of high-frquency ESR confirm the AFM ground state and suggest a zero field splitting of 16.5 GHz. For $B < B_{SF}$, static magnetization data exhibit an anomaly at around 5.5 K which may be associated with the evolution of an incommensurate AFM phase predicted by theory [1]. Zero-field μSR measurements do not confirm the presence of weak ferromagnetism below 41 K [1]. At high temperatures, the μSR spectra follow a general exponential behavior which corresponds to fluctuations of electronic moments. Below T_N, μSR spectra show damped oscillation because of well-defined static internal fields at the muon site implying long range magnetic ordering. The magnetic order parameter is extracted and a clear λ-like anomaly in the relaxation rate is observed at T_N.

[1] V. B. Nalbandyan et al. Inorg. Chem. 54, 1705 (2015)

MA 5.11 Mon 12:45 H34

Critical phenomena in uniformly frustrated systems — •Bhilahari Jeevanesan[1], Karim Mnasri[2], and Jörg Schmalian[1,3] — [1]Institute for Theory of Condensed Matter, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Institute of Theoretical Solid State Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [3]Institute for Solid State Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

The field theory and statistical mechanics of uniformly frustrated systems is frequently studied by placing systems in curved background geometries. We study the critical behavior of an N-component ϕ^4-theory in hyperbolic space, which has the role of uniformly frustrating the magnetic order described by ϕ. We treat this model in a 1/N expansion and find that it exhibits a second-order phase transition with an unusual magnetization texture that results from the lack of global parallelism in hyperbolic space. Angular defects occur on length scales comparable to the radius of curvature. This phase transition is governed by a new strong curvature fixed point that obeys scaling below the upper critical dimension $d_{uc} = 4$. The exponents of this fixed point are given by the leading order terms of the 1/N expansion.

MA 5.12 Mon 13:00 H34

Neutron Depolarisation Imaging of the Ferromagnetic Kondo Lattice System $CePd_{1-x}Rh_x$ — •Marc Seifert[1,2], Philipp Schmakat[1,2], Michael Schulz[2], Christoph Geibel[3], Micha Deppe[3], and Christian Pfleiderer[1] — [1]Technische Universität München, Physik-Department, D-84578 Garching, Germany — [2]Forschungs-Neutronenquelle FRM-II, D-84578 Garching, Germany — [3]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

The ferromagnetic Kondo lattice system $CePd_{1-x}Rh_x$ crystallises in the orthorhombic CrB crystal structure with a magnetic easy axis along the *c*-axis. We present a detailed neutron depolarisation study, where we oriented the *c*-axis of a $CePd_{1-x}Rh_x$ single crystal with $x = 0.40$ perpendicular to the polarisation of the neutron beam. Application of an external field of a few mT reveals an oscillation of the neutron polarisation signal close to the ferromagnetic ordering temperature at $T_c = 5.3$ K. We explain this oscillation with a Larmor precession of the polarisation vector around the stray field direction favoured due to anisotropy. Furthermore, we can extract the dc susceptibility, the angle between the magnetisation and polarisation, and the absolute value of the magnetisation from the oscillations. The values inferred are in good agreement with theoretical calculations.

MA 5.13 Mon 13:15 H34

Study of the Magnetic Excitations in the Dimer Compound Ba3-xSrxCr2O8 — •Alsu Gazizulina[1], Henrik Grundmann[1], Diana Quintero Castro[2], and Andreas Schilling[1] — [1]Physik-

Institut of University of Zurich, Zurich, Switzerland — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany

Spin dimer systems, such as Ba3Cr2O8 and Sr3Cr2O8 show a field induced phase transition that can be described in terms of a Bose-Einstein condensation (BEC) of magnetic quasiparticles (triplons) in connection with the collective dimer states. The respective critical fields of Ba3Cr2O8 and Sr3Cr2O8 differ strongly due to a large difference in the strength of the intradimer magnetic interaction constant J0. For the corresponding solid solution Ba3-xSrxCr2O8, the strength of this interaction constant has been reported to be tunable in a non-linear way in a wide range by changing the Sr content x. Recently, we were able to grow single crystal samples of Ba0.1Sr2.9Cr2O8 and Ba0.2Sr2.8Cr2O8. . Our initial results for Ba0.1Sr2.9Cr2O8 point out to an intradimer exchange coupling J0 to be 5.18 meV, smaller than the value for the pure compound Sr3Cr2O8 of 5.55 meV.