MA 28: Surface Magnetism I (jointly with O)

Time: Wednesday 9:30–12:00 Location: H31

MA 28.1 Wed 9:30 H31

Design and Synthesis of a Blatter Radical for Stable Thin Films — •Francesca Ciccullo[1], Nolan Gallagher[2], Andrzej Rajca Rajca[2], and Maria Benedetta Casu[1] — [1]Institute of Physical and Theoretical Chemistry, University of Tübingen, Auf der Morgenstelle 18, 72076 Tübingen, Germany — [2]Department of Chemistry, University of Nebraska, Lincoln, Nebraska 68588-0304, United States

Organic radicals are fascinating materials because of their unique properties, which make them suitable for a variety of possible applications. Their synthesis may be challenging and big efforts have focused on chemical stability. However, introducing a new material in electronics requires not only chemically stable molecules but also stable thin films in view of their use in devices. In this work we have synthesized and characterized a derivative of the Blatter radical, bearing in mind the thermodynamic factors that govern thin film stability. We have proved our concept by investigating the electronic structure, the paramagnetic character and stability of the obtained films under UHV and ambient conditions, by in-situ X-ray photoelectron spectroscopy, ex-situ atomic force microscopy and electron paramagnetic resonance spectroscopy.

MA 28.2 Wed 9:45 H31

Co-Salen on NiO(001): Indication of a superexchange mediated coupling between a magnetic molecule and an antiferromagnetic bulk insulating substrate — •Alexander Schwarz, Josef Grenz, and Roland Wiesendanger — INF (IAP), Fachbereich Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

Spin Polarized Scanning Tunneling Microscopy (SP-STM) and X-ray magnetic circular dichroism (XMCD) have been employed to detect the magnetic coupling between a magnetic surface and magnetic molecules adsorbed on top [1,2]. However, up to now only metallic substrates were investigated.

Here, we utilize Magnetic Exchange Force Microscopy (MExFM), which can be applied to insulating sample system [3]. This enables us to study the magnetic coupling between Co-Salen and the row-wise antiferromagnetically ordered spins on the (001) surface of a NiO single crystal, a wide band gap insulator. Using magnetically coated tips we find that Co-Salen molecules, which adsorb on neighboring oxygen rows, exhibit a significantly different apparent height. This observation can be explained by a magnetic contribution to the total tip-sample interaction. As on this substrate the molecule adsorbs with its central cobalt atom above oxygen, a superexchange mechanism could be responsible for the magnetic coupling between the spin-carrying nickel atoms of the subsurface layer and the cobalt atoms of the molecules.

[1] H. Wende at al., Nature Mat. **6**, 516 (2007).
[2] C. Iacovita et al., Phys. Rev. Lett. **101**, 116602 (2008).
[3] U. Kaiser, A. Schwarz, R. Wiesendanger, Nature **446**, 522 (2007).

MA 28.3 Wed 10:00 H31

Magnetic interlayer softening induced by molecular skyhook effect — •Rico Friedrich, Vasile Caciuc, Nicolae Atodiresei, and Stefan Blügel — Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

The ability to tune surface magnetic exchange interactions by the adsorption of nonmagnetic organic molecules has opened a new direction of molecular spintronics research in which the magnetic properties of a substrate can be patterned down to the molecular scale [1,2,3]. Phenalenyl-based molecules deposited on a Co(111) substrate can magnetically decouple the Co atoms below the molecule from the bulk Co substrate leading to an experimentally measured interface magnetoresistance [2]. By systematically investigating weakly and strongly chemisorbed molecules as dioxan and dioxin on the prototypical ferromagnetic substrate of 2 monolayers Fe on W(110) we show that the inter-layer magnetic softening is the consequence of an increased distance between the first layer magnetic atoms directly binding the molecule and the second layer [4]. This molecular induced skyhook effect is present for both weakly and strongly chemisorbed molecules. Moreover, by increasing the molecule-surface hybridization the interlayer magnetic softening is enhanced due to a chemical contribution.

[1] M. Callsen *et al.*, PRL **111**, 106805 (2013)
[2] K. V. Raman *et al.*, Nature **493**, 509 (2013)
[3] R. Friedrich *et al.*, PRB **91**, 115432 (2015)
[4] R. Friedrich *et al.*, PRB **92**, 195407 (2015)

MA 28.4 Wed 10:15 H31

Non-collinear magnetic order at room temperature — •Aurore Finco, Pin-Jui Hsu, Thomas Eelbo, Niklas Romming, André Kubetzka, Kirsten von Bergmann, and Roland Wiesendanger — Department of Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

Non-collinear magnetic structures like skyrmions are very promising for spintronics applications. They can be stabilized in ultrathin films by the Dzyaloshinskii-Moriya interaction induced by the interface between a heavy element substrate and the magnetic layer. Spin-polarized scanning tunneling microscopy is a very powerful tool to investigate these complex spin structures down to the atomic scale. Using this technique, it was shown that the magnetic structure of the 1st layer Fe on Ir(111) is a nanoskyrmion lattice below 30 K [1]. Going to higher Fe coverage, an increased thermal stability can be expected.

At low temperature, spin spirals guided by reconstruction lines (due to lattice mismatch between Fe and Ir) are visible on both the 2nd [2] and the 3rd layer Fe on Ir(111) with periodicities of about 1.5-2 nm and 4-9 nm respectively. While the 2nd layer does not respond to a magnetic field, the 3rd layer spirals transform into single distorted skyrmions under an out-of-plane field of about 2 T. In the absence of a field, the measurement temperature was raised up to room temperature. On the 2nd layer, the cycloidal spin spirals disappear above 150 K whereas the 3rd and 4th layers exhibit a non-collinear magnetic structure at room temperature with a periodicity of 30 to 60 nm.

[1] Sonntag et al, PRL, 113 077202 ; [2] Hsu et al, PRL, in press

15 min. break

MA 28.5 Wed 10:45 H31

Evidence for non-collinear surface magnetic order of Gd(0001) by spin-polarized scanning tunneling microscopy — •Matthias Vogt, Martin Schmitt, Jeannette Kemmer, and Matthias Bode — Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

We present spin-polarized scanning tunneling microscopy measurements of Gd(0001) films grown on W(110). In agreement with previous publications [1] we observed an exchange-split surface state with an occupied majority and an empty minority part. For film thicknesses between 6 and 240 atomic layers maps of the differential conductivity $\mathrm{d}I/\mathrm{d}U$ measured with magnetically coated probe tips show a magnetic structure which is dominated by six contrast levels. They represent magnetic domains which are most likely the consequence of the hexagonal Gd surface structure, which results in six equivalent easy axis, similar to earlier reports on Dy(0001) films [2]. Additionally, close inspection reveals weak intensity modulations within the domains with a periodicity of about 2 nm. Their amplitude is strongly bias dependent and varies for different domains. The fact that these modulations are absent if measured with non-magnetic tips indicates their magnetic origin. We will present different potential non-collinear spin configurations and discuss to what extend they agree with our experimental observations.

[1] M. Bode *et al.*, Phys. Rev. Lett. **81**, 4256 (1998).
[2] L. Berbil-Bautista *et al.*, Phys. Rev. B **76**, 064411 (2007).

MA 28.6 Wed 11:00 H31

Modification of spin Hamiltonian induced by molecular deformation of 3d β-diketonate complexes — •Hironari Isshiki, Jinjie Chen, Clemens Baretzky, Timofey Balashov, and Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institute of Technology

The magnetic anisotropy of a magnetic molecule is governed to the ligand field around the magnetic ion. The magnetic properties might be altered greatly by the deformation of the molecule. Recently, the tuning of magnetic anisotropy by molecular deformation of Fe-porphyrin was demonstrated [1].

Here, we investigated the alternation of magnetic properties by tip induced ligand deformation on 3d metals based β-diketonate complexes with scanning tunneling microscopy. We observed an inelastic excitation at 10 meV on a Co(II) molecule in dI/dV spectra, which is at-

tributed to a spin-flip excitation. Approaching the tip to the molecule, a discontinuous change in current was observed, indicating contact formation and molecular deformation. Accompanying the deformation, an appearance of a Kondo resonance and a shift of the energy of the inelastic excitation were observed. We carried out similar measurements on Ni(II) and Cu(II) molecules.

[1] Nano Lett., 2015, 15, 4024-4028

MA 28.7 Wed 11:15 H31

Local dynamics of topological magnetic defects imaged by magnetic force microscopy — •Peggy Schönherr[1], Anders Bergman[2], Markus Garst[3], Yoshi Tokura[4,5], Christian Degen[1], Manfred Fiebig[1], and Dennis Meier[1] — [1]ETH Zürich, Switzerland — [2]Uppsala University, Sweden — [3]Universität zu Köln, Germany — [4]University of Tokyo, Japan — [5]Riken, Japan

Chiral magnetic interactions induce complex spin textures, including helical and conical spin waves, as well as particle-like objects (skyrmions or merons), forming the basis for innovative device paradigms and exotic topological phenomena. Present key questions address the dynamics of the spin system and emergent topological defects. Here we discuss the micromagnetic dynamics in the helimagnetic phase of FeGe using magnetic force microscopic. We show that the nanoscale dynamics are governed by the depinning and subsequent motion of magnetic edge dislocations. The motion of these topologically stable objects triggers perturbations that can propagate over mesoscopic length scales. The experimental observation of stochastic instabilities in the micromagnetic structure provides new insight to the spatio-temporal dynamics of itinerant helimagnets and topological defects, and discloses novel challenges regarding their technological usage.

MA 28.8 Wed 11:30 H31

High frequency magnetization dynamics of individual atomic-scale magnets — •Stefan Krause, Andreas Sonntag, Jan Hermenau, Johannes Friedlein, and Roland Wiesendanger — Department of Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

Nucleation, annihilation and domain wall propagation are the most fundamental microscopic processes of magnetization reversal. Understanding and controlling these mechanisms is crucial for the development of future high-speed spintronic applications. In previous spin-polarized scanning tunneling microscopy (SP-STM) studies it was shown that the thermally activated magnetization reversal of Fe/W(110) nanomagnets consisting of less than 100 atoms is realized by nucleation and propagation instead of a coherent rotation of all magnetic moments. [1]

Within the present study we use SP-STM to investigate the magnetic ground state dynamics of individual nanomagnets over a wide temperature ($T = 30..70\,\mathrm{K}$) and switching rate ($\nu = 100\,\mathrm{mHz}..10\,\mathrm{MHz}$) regime, combining telegraphic noise analysis and pump-probe schemes. With increasing T a transition between two Arrhenius regimes is observed, resulting in switching rates that are by orders of magnitude lower than expected from an extrapolation from the low temperature regime. The experimental results will be presented and interpreted in terms of an analytical model that accounts for the interplay of T-dependent nucleation, annihilation and propagation rates.

[1] S. Krause *et al.*, Phys. Rev. Lett. **103**, 127202 (2009).

MA 28.9 Wed 11:45 H31

Dynamical para-spin-excitations in non-magnetic adatoms — •Julen Ibañez-Azpiroz, Manuel dos Santos Dias, Stefan Blügel, and Samir Lounis — Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

We find the presence of spin-excitation modes in non-magnetic adatoms, *i.e.* para-spin-excitation modes, the analogous of paramagnons in bulk materials. We show that their signature in the excitation spectrum can evolve a well-defined peak whose linewidth (*i.e.* inverse lifetime) is predominantly controled by the Stoner exchange parameter and the density of states near the Fermi level. Utilizing time-dependent density functional theory as implemented in the Korringa-Kohn-Rostoker Green function formalism, we explore the para-spin-excitations of various 4d transition-metal adatoms deposited on metallic substrates. Based on the Anderson impurity model, we identify the most favourable parameter setup for the appearance of such excitations. Finally, we simulate tunneling transport experiments to address the possibility of detecting these para-spin-excitations in inelastic scanning tunneling spectroscopy.

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