

O 13: Magnetic Surface Excitations

Time: Monday 15:00–17:30

Location: S052

Invited Talk

O 13.1 Mon 15:00 S052

Excitations and dynamics of non-collinear magnetization states in tailored adatom arrays — ●JENS WIEBE — Department of Physics, Universität Hamburg, D-20355 Hamburg, Germany

Arrays of magnetic atoms adsorbed on the surface of a non-magnetic metal can be tailored in topology [1], magnetic anisotropy [2,3], interactions [1,4], and Kondo coupling [3] by combining different substrate/adatom species with the manipulation- [1], spin-resolved- [5] and inelastic- [6] spectroscopy capabilities of the scanning tunneling microscope. Such arrays are perfect model systems to study the complex phase diagram of strongly correlated multi-orbital electron systems. Here, I will focus on the rich physics we recently discovered in arrays of iron adatoms on platinum(111) [2,3,7]. This system can be theoretically described within the Hund's metal framework. We can tune the individual constituents, the Hund's impurities, from a regime of emergent magnetism to a multi-orbital Kondo state [3]. By coupling a few Hund's impurities to arrays, we find non-collinear ground states induced by the substrate mediated Ruderman-Kittel-Kasuya-Yosida interaction [7]. I will present our investigation of the excitations and dynamics of such non-collinear magnetization states.

[1] A. A. Khajetoorians *et al.*, Nat. Phys. **8**, 497 (2012). [2] A. A. Khajetoorians *et al.*, PRL **111**, 157204 (2013). [3] A. A. Khajetoorians *et al.*, Nat. Nano. **10**, 958 (2015). [4] L. Zhou *et al.*, Nat. Phys. **6** 187 (2010). [5] J. Wiebe *et al.*, JPD **44**, 464009 (2011). [6] A. A. Khajetoorians *et al.*, Nature **467**, 1084 (2010). [7] A. A. Khajetoorians *et al.*, Nat. Comm., (accepted, 2015).

O 13.2 Mon 15:30 S052

Origin of inelastic excitations in rare-earth based metal-organic complexes — ●DANIELA ROLF¹, MATTHIAS BERNIEN¹, PAUL STOLL¹, QINGYU XU¹, FABIAN NICKEL¹, CLAUDIA HARTMANN¹, TOBIAS R. UMBACH¹, JENS KOPPRASCH¹, JANINA N. LADENTHIN¹, ENRICO SCHIERLE², EUGEN WESCHKE², CONSTANTIN CZEKELIUS³, WOLFGANG KUCH¹, and KATHARINA J. FRANKE¹ — ¹Freie Universität Berlin, Germany — ²Helmholtz-Zentrum Berlin für Materialien und Energie, Germany — ³Heinrich-Heine-Universität Düsseldorf, Germany

Rare-earth atoms with a partially filled f shell exhibit interesting magnetic properties due to their large magnetic anisotropy. Within the Dysprosium-tris(1,1,1-trifluoro-4-(2-thienyl)-2,4-butanedionate) (Dy(tta)₃) complex, Dy exhibits a total angular momentum of $J = 15/2$ with anisotropy-split M_J levels. Employing low-temperature STM we show that deposition of Dy(tta)₃ on a Au(111) surface leads to densely packed self-assembled islands. XMCD measurements on Dy(tta)₃ show a sizeable magnetic anisotropy. dI/dV -spectra on these molecules exhibit symmetric steps at ± 7.6 meV, which correspond to an inelastic excitation. To identify the origin of this feature unambiguously, we compare to spectra taken on the isostructural Gd(tta)₃, showing an inelastic step at a similar energy. As Gd³⁺ has a half-filled f shell, it is not expected to show any magnetic anisotropy. Hence, we conclude that the inelastic steps do not arise due to transitions between the anisotropy-split spin states, but can be explained by the excitation of molecular vibrations.

O 13.3 Mon 15:45 S052

Tuning the Kondo coupling strength of a single molecule — ●OLOF PETERS¹, BENJAMIN W. HEINRICH¹, CHRISTIAN LOTZE¹, XI-ANWEN CHEN¹, MARKUS TERNES², and KATHARINA J. FRANKE¹ — ¹Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — ²Max-Planck Institut für Solid State Research, Stuttgart, Germany

Metal adatoms on a metal surface are typically strongly Kondo coupled, leading to a high Kondo temperature T_K , whereas insulating films efficiently reduce the coupling of such adsorbates resulting in much lower T_K . This decoupling gives the opportunity to study the Kondo effect with today's accessible magnetic fields and temperature ranges. A disadvantage of these isolating layers is the fixed coupling constant determined by the specific system.

We report on the controllable, continuous and reversible tuning of the Kondo coupling between a metal-organic complex (Fe-octaethylporphyrin-Cl) and its underlying Au(111) metal surface under the influence of a scanning tunnelling microscope tip at 1.1 K. Upon approach of the STM tip to the Fe core, the magnetic anisotropy

increases and eventually a Kondo resonance appears. The Kondo coupling strength continuously increases at further tip approach.

We ascribe these results to a modification of the crystal field by the tip leading to a shift in the d-level energies. The change in crystal field also results in a relaxation of the Fe atom towards the substrate thus tuning the magnetic interactions from weak into the strong Kondo coupling regime.

O 13.4 Mon 16:00 S052

Reversible switching of the Kondo effect at a giant Rashba surface — ●JENS KÜGEL, ANDREAS KRÖNLEIN, and MATTHIAS BODE — Experimentelle Physik II, Würzburg, Germany

Transition metal phthalocyanine (TMPC) molecules on metal substrate have recently attracted considerable interest, as they offer a versatile platform to study and tune magnetic interaction of the central metal ion with the substrate's conduction electrons [1,2]. Especially the Kondo effect arising from unscreened magnetic moments of the metal ion has been intensively studied [3,4].

In this contribution we present a low-temperature ($T = 5$ K) scanning tunneling microscopy and spectroscopy (STS) study of single MnPc molecules adsorbed on BiAg₂, a surface alloy which has been shown to exhibit a giant Rashba effect [5]. We will show that a STS feature close to the Fermi energy —most likely a signature of Kondo screening— can be reversibly switched on and off by controlled manipulation with the STM tip.

- [1] A. Zhao *et al.*, Science **309**, 1542 (2005).
 [2] J. Kügel *et al.*, Phys. Rev. B **91**, 235130 (2015).
 [3] D. Rakhmievitch *et al.*, Phys. Rev. Lett. **113**, 236603 (2014).
 [4] A. Strozecka *et al.*, Phys. Rev. Lett. **109**, 147202 (2012).
 [5] C. R. Ast *et al.*, Phys. Rev. Lett. **98**, 186807 (2007).

O 13.5 Mon 16:15 S052

Tailoring the magnetic ground state of a two-molecule Kondo system by chemical interactions — ●T. ESAT¹, B. LECHTENBERG², T. DEILMANN³, C. WAGNER¹, P. KRÜGER³, R. TEMIROV¹, M. ROHLFING³, F.B. ANDERS², and F.S. TAUTZ¹ — ¹Peter Grünberg Institute (PGI-3), FZ Jülich, Germany — ²Institut für Festkörpertheorie, Universität Münster, Germany — ³Lehrstuhl für Theoretische Physik II, TU Dortmund, Germany

Molecules are considered to be a promising platform for spintronics since self-assembly offers the opportunity to create tailored arrays of single spins. In this context, engineering the interaction between spins is crucial for future applications.

Rather than relying on the magnetic exchange interaction to tailor the magnetic properties of a nanostructure, we propose a novel approach to achieve the same goal: it relies on the systematic use of the ubiquitous non-magnetic chemical interaction between the constituents of the nanostructure. Our approach is crucially based on spin-moment carrying orbitals that are extended in space [1] and therefore allow the direct coupling of magnetic properties to wave function overlap, i.e. the formation of chemically bonding and anti-bonding orbitals. We demonstrate the approach for a dimer of metal-molecule complexes on the Au(111) surface. Changing the wave function overlap between the two monomers, we tune the dimer through a quantum phase transition from a triplet to a singlet ground state, with one configuration being located extremely close to a quantum critical point.

- [1] T. Esat *et al.*, Phys. Rev. B **91**, 144415 (2015)

O 13.6 Mon 16:30 S052

The effect of surface oxidation on spin scattering for the W(110) surface — ●STEPHAN BOREK¹, JÜRGEN BRAUN¹, JAN MINÁR^{1,2}, DIMA KUTNYAKHOV³, HANS-JOACHIM ELMERS³, GERD SCHÖNHENSE³, and HUBERT EBERT¹ — ¹Ludwig-Maximilians-Universität München — ²University of West Bohemia Pilsen — ³Johannes-Gutenberg-Universität Mainz

It is well known that the W(110) surface possess interesting properties due to spin-orbit induced splitting of surface states. In our work we investigated the spin-orbit induced scattering of electrons from a clean W(110) surface using corresponding diffraction patterns to get an overview on the scattering behaviour. It was found that an oxygen passivation of the W(110) surface with a full oxygen overlayer has a huge impact on the electron diffraction. The oxidation of the

W(110) surface reduces the spin-orbit asymmetry and the figure of merit whereas the reflectivity is increased. To investigate the surface electronic structure we calculated angle-resolved photoemission spectra using the fully-relativistic one-step model. Additionally, we will discuss the impact of full potential calculations on the spin-resolved diffraction patterns of spin-polarized electrons.

O 13.7 Mon 16:45 S052

Tuning magnetic coupling between organic-metal hybrids mediated by a nanoskymion lattice — ●MACIEJ BAZARNIK¹, JENS BREDE², and ROLAND WIESENDANGER¹ — ¹Dept. of Physics, University of Hamburg, Jungiusstrasse 11, D-20355 Hamburg, Germany — ²Donostia International Physics Center, Paseo Manuel de Lardizabal 4 20018 Donostia - San Sebastian, Spain

Molecular spintronic devices offer great potential for future energy-efficient information technology as they combine ultimately small size, high-speed operation, and low-power consumption. There are two approaches to molecular spintronics: first, to utilize the intrinsic properties of molecules by depositing them on weakly interacting surfaces like thin film insulators, graphene, or gold; second, to make use of new properties of organic-metal hybrids created by strong hybridization of molecular orbitals with the substrate such as iron films on iridium [1].

Here, we take the latter approach to control the magnetic properties of organic-metal hybrids and tune the magnetic coupling. We show how to position fullerene molecules on the skyrmionic lattice of a single atomic layer of iron on an iridium substrate utilizing the STM-based atomic manipulation techniques, in order to tune the magnetic interactions between them.

[1] J. Brede *et al.* Nature Nano. 9 (2014) 1018-1023

O 13.8 Mon 17:00 S052

Spin manipulation by creation of single-molecule radical cations — ●SUJOY KARAN^{1,2}, NA LI³, YAJIE ZHANG⁴, YANG HE³, I-PO HONG³, HUANJUN SONG⁴, JING-TAO LÜ⁵, YONGFENG WANG^{1,3}, LIANMAO PENG³, KAI WU⁴, GEORG S. MICHELITSCH⁶, REINHARD J. MAURER⁶, KATHARINA DILLER⁶, KARSTEN REUTER⁶, ALEXANDER WEISMANN¹, and RICHARD BERNDT¹ — ¹Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93053 Regensburg, Germany — ³Key Laboratory for the Physics and Chemistry of Nanodevices, Department of Electronics, Peking University, Beijing 100871, P. R. China

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All-trans-retinoic acid (ReA), a closed-shell organic molecule comprising only C, H, and O atoms, is investigated on a Au(111) substrate using scanning tunneling microscopy and spectroscopy. In dense arrays single ReA molecules are switched to a number of states, few of which carry a localized spin as evidenced by conductance spectroscopy in high magnetic fields. The spin of a single molecule may be reversibly switched on and off without affecting its neighbors. We suggest that ReA on Au is readily converted to a radical by the abstraction of an electron.

O 13.9 Mon 17:15 S052

Enantiomer-dependent spin orientation in photoelectron transmission through heptahelicene molecules — ●MATTHIAS KETTNER¹, JOHANNES SEIBEL², DANIEL NÜRENBERG¹, KARL-HEINZ ERNST², and HELMUT ZACHARIAS¹ — ¹University of Münster, Center for Soft Nanoscience and Physikalisches Institut, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany — ²EMPA, Nanoscale Materials Science, Überlandstrasse 129, 8600 Dübendorf, Switzerland

The interaction of electrons with helical molecules attains growing interest due to a spin selectivity in electron transmission. Experiments on self-assembled monolayers of double stranded DNA and oligopeptides [1] indicated a very efficient spin filtering behavior of the molecules at room temperature.

In present experiments enantiopure M- and P-heptahelicene molecules are evaporated onto different metal single crystal surfaces. The molecules arrange themselves to a highly ordered monolayer [2]. Samples are then irradiated with $\lambda = 213\text{nm}$ laser radiation to generate photoelectrons from the substrate. These electrons are transmitted through the heptahelicene layer and analyzed with regard to their average longitudinal spin orientation by Mott scattering. The sign of the spin polarization depends on the helicity of the enantiomer. The effect of the heptahelicene on the spin orientation seems to be independent on the substrate.

References

[1] Kettner, M. *et al.*, J.Phys.Chem. C 2014, 119, 26

[2] Seibel, J. *et al.*, J.Phys.Chem. C 2014, 118, 29135