MA 16: Surface Magnetism (joint session O/MA)

Time: Tuesday 10:30–13:00 Location: H37

MA 16.1 Tue 10:30 H37

Unoccupied surface and interface states in thin film of Pd deposited on Fe/Ir(111) surface — •Mohammed Bouhassoune, Imara Lima Fernandes, Stefan Blügel, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

Pd layer deposited on Fe/Ir(111) substrate has been recently subject to intensive investigations since it hosts small swirling spin-textures named skyrmions that have potential interest in spintronic devices as magnetic bits for information technology. To manipulate and stabilize such non-collinear magetic objects it is of important demand to conduct a quantitaive study of their electronic structure. Here we aim to investigate the unoccupied states in Pd thin layers deposited on Fe/Ir(111) substrate using density functional theory. These unoccupied states are behind the large spin-mixing magnetoresisatnce (XMR) signature measured using non spin-polarized scanning tunnelling microscopy (STM) [1,2]. By analysing the electronic band structure we demonstrate the emergence of surface and interface states after deposition of Pd monolayers, which are very sensitive to the large spin-orbit coupling of Ir surface giving rise to the XMR signal.

This work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (ERC-consolidator Grant No. 681405 DYNASORE).

[1] D. M. Crum, M. Bouhassoune, J. Bouaziz, B. Schweflinghaus, S. Blügel, and S. Lounis, Nat. Commun. 6 8541 (2015)

[2] C. Hanneken et al, Nat, Nanotech. 10, 1039 (2015)

MA 16.2 Tue 10:45 H37

Investigation of Fe/Pt (110) magnetic structure by first-principles methods — •Vasily Tseplyaev, Jens Bröder, Markus Hoffmann, Daniel Wortmann, Bernd Zimmermann, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

While skyrmions - localized and topologically protected vortex-like magnetic textures - are the main focus within the current research field of chiral magnets, we have discussed in a recent work [1] the possible emergence of interface stabilized *antiparticles*, so-called antiskyrmions, magnetic textures with a topological charge and one-dimensional winding number opposite to the one of skyrmions. For instance, antiskyrmions can appear in ultrathin magnetic films grown on heavy metal substrates with C_{2v} symmetry, if the electronic structure supports a Dzyaloshinskii spiralization tensor that fulfils additional conditions e.g. its determinant is smaller than zero. With the motivation to find interesting antiskyrmion systems we investigate magnetic systems with C_{2v} interface symmetry, e.g. Fe/Pt(110), using relativistic and non-collinear first-principles theory implemented in the FLEUR code (www.flapw.de).

[1] M. Hoffmann *et al.*, Nat. Commun. **8**, 308 (2017)

MA 16.3 Tue 11:00 H37

Yu-Shiba-Rusinov states of Fe atoms on 2H-$NbSe_2$ — •Eva Liebhaber[1], Rojhat Baba[1], Jannik Steinborn[1], Gaël Reecht[1], Sebastian Rohlf[2], Kai Rossnagel[2], Benjamin W. Heinrich[1], Felix von Oppen[1,3], and Katharina J. Franke[1] — [1]Fachbereich Physik, Freie Universität Berlin, Germany. — [2]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany. — [3]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Germany.

A magnetic impurity adsorbed on a superconducting substrate induces Yu-Shiba-Rusinov (YSR) states. These are low-energy bound states inside the superconducting energy gap. The symmetry and extent of the YSR wave function depends on the adsorption site (i.e. crystal field), the nature of the orbital hosting the impurity's spin and the shape of the Fermi surface of the substrate.

We investigate single Fe atoms on 2H-$NbSe_2$. 2H-$NbSe_2$ belongs to the class of transition metal dichalcogenides (TMDCs) and is a layered van der Waals material with strong 2D character. In this material, superconductivity coexists with a charge density wave (CDW) at low temperatures. As the CDW is incommensurate with the lattice there are different local charge modulations present on the surface. Hence, adatoms sitting in identical hollow sites differ in their position relative to the CDW leading to variations in symmetry and energy of the YSR resonances.

MA 16.4 Tue 11:15 H37

Epitaxial growth of the ultrathin EuS films on the InAs(001) and magnetic coupling between these films and organometallic phthalocyanine monolayers — •Carmen González Orellana, Maxim Ilin, and Celia Rogero — Centro de Física de Materiales, San Sebastián, Spain

EuS has recently attracted a lot of interest because of its ability of creating strong exchange fields when its placed in contact with non-ferromagnetic materials. For instance, at the interface between EuS and the topological insulator Bi_2Se_3, interfacial ferromagnetism was found to persist up to room temperature, despite the low Tc of bulk EuS (16.6 K). Furthermore, the formation of a new ferromagnetic ground state of the Dirac electrons in graphene was inferred on the basis of the electrical characterization of devices featuring a graphene/EuS interface.

I will present results of our work aimed to study the properties of the ultrathin EuS films and the interfaces between EuS and the organometallic pthalocyanines. We have optimized the epitaxial growth of EuS ultrathin films (< 1nm) on single crystal semiconducting InAs(001) substrates and characterized their structural and magnetic properties using LEED, STM, XPS, ex-situ magnetometry and in-situ XMCD techniques. Furthermore, we have grown monolayers of organometallic pthalocyanines (CuPC and MnPC) and performed XMCD measurements to probe the difference in the exchange coupling of the paramagnetic molecules with metallic (Ni, Co) and semiconducting (EuS) ferromagnets.

MA 16.5 Tue 11:30 H37

Coordination-induced spin-state switching of a Ni complex on Ag(111) — •Manuel Gruber[1], Alexander Köbke[1], Florian Gutzeit[2], Rainer Herges[2], and Richard Berndt[1] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [2]Institut für Organische Chemie, Christian-Albrechts-Universität zu Kiel, Germany

The spin state of a transition-metal complexes (TMC) can be controlled by changing its coordination state. For TMC on surfaces, this was so far realized by adding/removing gaseous molecules [1] or by transferring a ligand (e.g. Cl) with the tip of a scanning tunneling microscope (STM) [2]. Alternatively, a switching unit within the TMCs itself may be employed to change the coordination state of the complex [3], but so far the interaction with the substrate was detrimental for the molecular structure and switching properties [4].

In the present study, we have designed and investigated robust Ni complexes, which can intrinsically switch their coordination state. Combining low-temperature scanning tunneling microscopy, near-edge x-ray absorption spectroscopy along with density functional theory calculations, we evidence the switching of these complexes on Ag(111) between the S=0 and S=1 spin states.

This work was supported by the DFG through SFB 677 and the European Union's Horizon 2020 programme (No. 766726). [1] Gopakumar et al., J. Am. Chem. Soc. **134**, 11844 (2012) [2] Wäckerlin et al., Adv. Mater. **25**, 2404 (2013) [3] Venkataramani et al., Science **331**, 445 (2011) [4] Matino et al., Chem. Commun. **46**, 6780 (2010)

MA 16.6 Tue 11:45 H37

Magnetic order in Nd(0001): a new type of spin glass? — •Umut Kamber, Andreas Eich, Nadine Hauptmann, Daniel Wegner, and Alexander A. Khajetoorians — Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands

Lanthanide metals can exhibit complex magnetic structures, e.g. helical/conical spin spirals or linear spin waves. Neodymium (Nd) shows the most complicated behavior exhibiting several magnetic phase transitions below TN = 19.9 K, resulting in multi-q order according to interpretations based on magnetic neutron or X-ray diffraction experiments [1]. However, as these techniques lack spatial resolution, the variations in magnetic properties of Nd at the atomic length scale are unexplored. The local surface electronic structure of Nd(0001) has been studied only using spin-integrated STS [2,3]. Here, we present

ultra-low temperature SP-STM measurements of bulk-like Nd(0001) films grown on W(110). We observe multi-q magnetic behavior on the surface as evidenced by strong short-range order, but without the existence of long-range order. Magnetic field and temperature-dependent measurements reveal high sensitivity of the spectral weight of q-states to applied fields, without any clear unique ground state, as well as evidence of aging behavior in the magnetic state. We discuss our findings in the context of unconventional spin-glass behavior. [1] R. M. Moon & R. M. Nicklow, J. Magn. Magn. Mater. 100, 139 (1991). [2] D. Wegner et al., Phys. Rev. B 73, 165415 (2006). [3] D. Wegner et al., Jpn. J. Appl. Phys. 45, 1941 (2006).

MA 16.7 Tue 12:00 H37

On the magnetic coupling characteristics of endohedral fullerenes on Au(111) and Cu(111) by scanning tunneling microscopy (STM)/ spectroscopy (STS) and X-ray magnetic circular dichroism (XMCD) — •Emmanouil Koutsouflakis, Lukas Spree, Georgios Velkos, Yaofeng Wang, Sebastian Schimmel, Danny Baumann, Bernd Büchner, Christian Hess, and Alexey Popov — IFW-Dresden, 01069 Dresden, Germany

Single-Molecule Magnets (SMMs) are molecular materials whose molecules may exhibit magnetic properties such as magnetization under zero-field conditions, large relaxation times and high blocking temperatures. Towards molecular electronics and the subsequent controlled manipulation of single spins in SMMs, the obstacle of the insufficient chemical stability of many SMM architectures has to be overcome, in order to facilitate both their organization on substrates and the preservation of their properties.

We report on the alternatives of Trimetallic Nitrides (TNTs) and Dimetallic Fullerenes. TNTs are of the type $A_{3-n}B_nN@C_{80}$ (n=0-3; A, B rare earth metals or transition metals) where a carbon cage encapsulates a triangular cluster of three rare earth/ transition metal atoms and a nitrogen at its center. In dimetallic fullerenes the cluster is consisted of two lanthanide ions forming a covalent bond by an unpaired electron. In situ sub-monolayers on Au(111) and Cu(111) substrate have been developed under UHV conditions and STM/ STS and XMCD techniques have been applied to investigate the disruptive effects that arise on depositing SMMs onto reactive metal surfaces.

MA 16.8 Tue 12:15 H37

Effect of the Li doping on the Curie temperature of the GdAu2 surface alloy — •M. Ilyn[1,2], M. Gobbi[1,2], C. Rogero[1,2], P. Gargiani[3], M. Valbuena[4], C. Moreno[4], A. Mugarza[4,5], and F. Schiller[1,2] — [1]Materials Physics Center CSIC-UPV-EHU — [2]Donostia International Physics Center — [3]ALBA Synchrotron — [4]Catalan Institute of Nanoscience and Nanotechnology (ICN2) — [5]ICREA Institució Catalana de Recerca i Estudis Avançats

Magnetic surface alloys REAu2 (where RE stands for the rare-earth elements) are the two-dimensional counterparts of the 3-D intermetallic compounds. They were found to be a model system to study the magnetic phenomena in 2-D metallic materials. Indeed, grown on the single-crystal substrates they have atomically-flat surface and a long-range crystallographic order, allowing for use of all standard surface science techniques. On the other hand, magnetic properties of this system can be tuned via choosing the RE element or a noble metal of the substrate.

In this talk I will present results that show the effect of Li doping on the magnetic properties of GdAu2 surface alloy. Previously we have seen that GdAu2 retains its magnetic properties when it is interfaced with organic layers and sustains a thermally activated dehalogenation reaction, but its Curie temperature (Tc) decreases. New XMCD measurements demonstrate a strong (by 60%) growth of the Tc in GdAu2 due to the evaporation of the submonolayer amount of Li. These data together with results of the XPS and ARPES measurements will be used to discuss the mechanism of the observed phenomena.

MA 16.9 Tue 12:30 H37

Disentangling spin-dependent scattering processes in thin Tb and Gd films — Gesa Siemann, •Wibke Bronsch, Beatrice Andres, and Martin Weinelt — Freie Universität Berlin, Deutschland

Studying the magnetic phase transition in thin Gd and Tb films by spin-resolved photoemission spectroscopy, we evaluated the linewidth of the (0001) surface state as a function of temperature in accordance with Ref.[1]. We observe different linewidths for the majority and minority spin components of the spin-mixed occupied surface state indicating differing scattering channels and concomitant spin-dependent lifetimes. A linear increase of the linewidth with temperature for $T > T_{\mathrm{Debye}}$ allows us to evaluate the electron-phonon scattering rate. We find a larger slope for the majority-spin channel compatible with the higher density of bulk states for majority spin electrons at $T < T_{\mathrm{Curie}}$. Furthermore, we observed a greater Lorentz width for the minority-spin component, which is attributed to electron-magnon scattering. The contributions of electron-phonon and electron-magnon scattering to the linewidth of the surface state are comparable for Gd and Tb.

[1] Fedorov *et al.*, Phys. Rev. B **65**, 212409 (2002)

MA 16.10 Tue 12:45 H37

Disentangling the double-exchange and superexchange interactions in quantum anomalous Hall insulators — •Thiago R. F. Peixoto[1], Hendrik Bentmann[1], Abdul-Vakhab Tcakaev[2], Philipp Rüssmann[3], Raphael Crespo Vidal[1], Sonja Schatz[1], Fabian Stier[2], Volodymyr Zabolotnyy[2], Martin Winnerlein[4], Steffen Schreyeck[4], Charles Gould[4], Karl Brunner[4], Stefan Blügel[3], Laurens W. Molenkamp[4], Vladimir Hinkov[2], and Friedrich Reinert[1] — [1]Experimentelle Physik VII, Universität Würzburg — [2]Experimentelle Physik IV, Universität Würzburg — [3]Peter Grünberg Institut (PGI-1), Forschungszentrum Jülich — [4]Experimentelle Physik III, Universität Würzburg

We report on the electronic origin of the magnetic properties of the quantum Hall insulators (V,Cr):$(Bi,Sb)_2Te_3$. By combining x-ray magnetic circular dichroism (XMCD), resonant photoemission spectroscopy (resPES) and density functional theory (DFT), we trace element-specific fingerprints in the valence band and magnetic coupling mechanisms. Our results show that while the low spectral weight of Cr $3d$ states at the Fermi level (E_F) support the presence of ferromagnetic superexchange interactions, an additional double-exchange interaction is intimately related to a highly localised V $3d$ impurity band at E_F. Furthermore, we show that a Bi-rich host increases the covalency of the transition metal ions, thereby mitigating Hund's rule stabilisation. The competition between charge-transfer and pd-exchange ultimately determines the magnetic ground-state in these systems [1].

[1] Larson and Lambrecht, Phys. Rev. B **78**, 195207 (2008).