O 31: Surface and Interface Magnetism I (jointly with MA)

Time: Tuesday 10:30–13:15 Location: H33

O 31.1 Tue 10:30 H33

Magnetism of Fe on Pt(111) Revisited by Inelastic Scanning Tunneling Spectroscopy — Tobias Schlenk, Alexander Ako Khajetoorians, •Jens Wiebe, and Roland Wiesendanger — Institute of Applied Physics, Hamburg University, Germany

We revisited the magnetism of single Fe atoms [1] and Fe-H_n complexes adsorbed on the surface of Pt(111) by means of magnetic field dependent inelastic scanning tunneling spectroscopy [2,3]. We found that the magnetic easy axis is either perpendicular to or within the surface plane, depending on an fcc or hcp adsorption site. Adsorption of H atoms changes the strength of the magnetic anisotropy and leads to Kondo screening for one of the two Fe-H_2 complexes. For all investigated cases, the magnetic anisotropy energy is almost an order of magnitude lower than recently reported [1].

[1] T. Balashov *et al.*, Phys. Rev. Lett. **102**, 257203 (2009).

[2] A. A. Khajetoorians, S. Lounis, B. Chilian, A. T. Costa, L. Zhou, D. L. Mills, J. Wiebe, and R. Wiesendanger, Phys. Rev. Lett. **106**, 037205 (2011).

[3] B. Chilian, A. A. Khajetoorians, S. Lounis, A. T. Costa, D. L. Mills, J. Wiebe, and R. Wiesendanger, Phys. Rev. B **84**, 212401 (2011).

O 31.2 Tue 10:45 H33

Structure Driven Complex Magnetic Ordering of a CoO Overlayer on Ir(100) — •Florian Mittendorfer[1], Josef Redinger[1], Raimund Podloucky[2], and Michael Weinert[3] — [1]Inst. of Applied Physics, TU Vienna — [2]Inst. of Physical Chemistry, Univ. Vienna — [3]Univ. Wisconsin-Milwaukee

The adsorption of a mono-layer thick magnetic oxide film on an unmagnetic substrate offers a playground to study the relation between the geometrical structure and the magnetic properties of the film.

I will present our recent results on the magnetic ordering in the ultrathin hexagonal c(10x2) CoO(111) film supported on Ir(100) [1], obtained on the basis of ab initio calculations with the Vienna Ab-initio Simulations Package (VASP). We find a close relationship between the local structural properties of the oxide film and the induced magnetic order, leading to alternating ferromagnetically and antiferromagnetically ordered segments. While the local magnetic order is directly related to the geometric position of the Co atoms, the mismatch between the CoO film and the Ir substrate leads to a complex long-range order of the oxide.

[1] Phys. Rev. Lett. 109 (2012) 015501.

O 31.3 Tue 11:00 H33

Detecting and Interpreting Spin-Dependent Dissipation Observed with Magnetic Exchange Force Microscopy and Spectroscopy — •Alexander Schwarz, Rene Schmidt, Elena Y. Vedmedenko, and Roland Wiesendanger — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

Magnetic exchange force microscopy (MExFM) and spectroscopy (MExFS) can resolve magnetic surfaces and probe the distance dependence of the magnetic exchange interaction with atomic resolution [1,2]. In both cases the frequency shift of an oscillating cantilever due to conservative tip-sample interactions is detected. By recording the amplitude and the excitation amplitude required to keep the amplitude of the cantilever oscillation constant, the energy loss due to dissipative processes can be determined. It turns out, that this signal can be spin-dependent as well [2,3]. The possible origin of this signal will be discussed in terms of spin-excitations [4] and spin-dependent adhesion-hysteresis [3]. Additionally, it will be shown how the dissipation signal can be used to characterize the tip, which is very important to correctly evaluate force spectroscopy data quantitatively.

[1] U. Kaiser, A. Schwarz and R. Wiesendanger, Nature 446, 522 (2007).

[2] R. Schmidt, A. Schwarz, and R. Wiesendanger, Phys. Rev. Lett. 106, 257202 (2011).

[3] E. Y. Vedmedenko et al., Phys. Rev. B 85, 174410 (2012).

[4] F. Pellegrini, G. E. Santoro, and E. Tosatti, Phys. Rev. Lett. 105, 146103 (2010).

O 31.4 Tue 11:15 H33

Zeeman splitting in superconducting scanning tunneling microscopy tips — •Matthias Eltschka[1], Berthold Jäck[1], Maximilian Assig[1], Markus Etzkorn[1], Christian R. Ast[1], and Klaus Kern[1,2] — [1]Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany — [2]Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

Scanning tunneling microscopy (STM) is a powerful technique to investigate a manifold of physical and chemical phenomena at the atomic scale. For spin-dependent tunneling, superconducting STM tips are of particular interest due to the well-known spin-polarization of almost 100%, especially in combination with high energy resolution at ultra-low temperatures.

We present STM experiments on a V(100) sample in combination with several V-tips at milli-Kelvin temperatures. The applied magnetic fields exceed the critical magnetic field of bulk V, so that the sample is in the normal conducting state. Due to its reduced dimensions the tip apex remains superconducting in fields up to 10 H_c (bulk). Our evaluation of the experimental data is based on Maki's model taking into account effects of orbital depairing and spin orbit coupling [1, 2]. Zeeman splitting of the superconducting quasi-particle densities of states is observed on several V-tips. Further, the quenching process of the superconducting gaps of the V-tips is investigated as function of magnetic fields.

[1] K. Maki, Prog. Theor. Phys. 32, 29 (1964)

[2] R. Meservey et al., Phys. Rev. B 11 4224 (1975)

O 31.5 Tue 11:30 H33

Wave function imaging of transition metal impurities near the H/Si(111) surface — •Benjamin Geisler and Peter Kratzer — Fakultät für Physik and Center for Nanointegration, Universität Duisburg-Essen, 47048 Duisburg, Germany

Despite the difficulties encountered in fabricating magnetic semiconductors, doping of silicon by 3d transition metals is an interesting topic in the field of spintronics. Imaging of electronic states on the atomic scale is possible with state-of-the-art scanning tunneling microscopy (e.g., Jancu *et al.*, PRL 2008, for Mn:GaAs) and can improve the understanding of impurity-host and impurity-impurity interactions.

Here we present an *ab initio* viewpoint on Cr, Mn and Fe impurities near the H/Si(111) surface, which has the specialty of providing a similar chemical environment as bulk Si does, while keeping the impurities accessible to surface analysis techniques. According to our calculations, subsurface doping through the H layer is possible. We discuss magnetic and energetic characteristics of isolated impurities and their detection with (magnetic) scanning tunneling microscopy, which is able to discriminate between interstitial and substitutional defects of different depth. Furthermore, delta layers and 2D clusters of interstitial impurities and their magnetic properties are shown. We find that the impurity wave functions are less extended than those of Mn in GaAs, which makes it harder to get ferromagnetic coupling in Si.

O 31.6 Tue 11:45 H33

First-principles investigation of self energies and theoretical magnetic excitation spectra — •Benedikt Schweflinghaus[1], Manuel Dos Santos Dias[1], Antonio Costa[2], and Samir Lounis[1] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany — [2]Instituto de Física, Universidade Federal Fluminense, 24210-340 Niteroi, Rio de Janeiro, Brazil

Access to magnetic excitation spectra of single atoms deposited on surfaces is nowadays possible by means of low-temperature inelastic scanning tunneling spectroscopy, see e.g. [1]. A theoretical description of these spectra is accessible through the self energy which describes the coupling of the tunnelling electrons and the spin excitation within the adsorbate. We compute this quantity from first-principles utilizing the Korringa-Kohn-Rostoker Green function method combined with time-dependent density functional theory.

We will present results obtained for single 3d transition-metal adatoms placed on Cu(111) as well as on Pt(111) and proceed to a comparison with available experimental data. In particular, we will show how the imaginary part of the self energy, which essentially describes the lifetime of the excitation, is related to the local density of states as well as to the local dynamical magnetic susceptibility.

This work is supported by the HGF-YIG Programme (VH-NG-717 Funsilab).

[1] A. A. Khajetoorians et al., Phys. Rev. Lett. 106, 037205 (2011)

O 31.7 Tue 12:00 H33

Anisotropic charge oscillations induced by non-magnetic impurities on Fe/W(001) — •Mohammed Bouhassoune, Bernd Zimmermann, Phivos Mavropoulos, Daniel Wortmann, Peter H. Dederichs, Stefan Blügel, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

It has been shown recently that impurities embedded in the surface of few monolayers of Fe deposited on W(001) can trigger intriguing anisotropic charge oscillations [1]. This behavior exhibits a strong dependence on the thickness of the Fe film. Combining first-principles methods: the full-potential linearized augmented plane waves method [2] and the full-potential Korringa-Kohn-Rostoker Green function method [2], we investigate this peculiar behavior by considering single oxygen impurities and find that the anisotropic focused charge oscillations are substantially spin-dependent and are only present when the thickness of the Fe film equals 3 monolayers. We relate this effect to spin-dependent features of the two-dimensional Fermi contours that are crucially affected by the thickness of Fe films.

This work is supported by the HGF-YIG Programme FunSiLab –Functional Nanoscale Structure Probe and Simulation Laboratory (VH-NG-717).

[1] K. Von Bergmann, PhD Thesis, University of Hamburg (2004)
[2] www.juDFT.de

O 31.8 Tue 12:15 H33

Tunable Kondo resonance of Co atoms on Ag(111) — •María Moro[1,2], David Serrate[1,2], Marten Piantek[3], José Ignacio Pascual[4], and Manuel Ricardo Ibarra[1,2] — [1]Instituto de Nanociencia de Aragón and Laboratory for Advanced Microscopy, University of Zaragoza, Spain — [2]Dpto. Física de Materia Condensada, University of Zaragoza, Spain — [3]Instituto de Ciencias de Materiales de Aragón (ICMA), Spain — [4]Nanoscience Cooperative Research Center (CIC Nanogune)

The magnetic properties of atoms on metals are inherently connected with manybody interactions between the localized magnetic moment and the supporting surface. The Kondo effect is the one most frequently found. The energy scale of a Kondo ground state depends strongly on the exchange coupling between atom and surface and, consequently, on the surface local density of states at the Fermi level (LDOS). Here, we study the effect of the LDOS on the magnetic ground state of Co atoms on Ag(111) by constructing artificial atomic structures, which confine surface states electrons and modulate in a predesigned manner the LDOS. By intentionally placing individual atoms at sites with difference LDOS, the Kondo temperature can be varied between 60 to 145 K, demonstrating the precise control of the substrate LDOS is crucial for quantitative analysis of the Kondo state.

O 31.9 Tue 12:30 H33

Controlling spin stability by a vector magnetic field and atom manipulation — •Deung-Jang Choi[1,2], Shichao Yan[1,2], and Sebastian Loth[1,2] — [1]Max Planck Research Group-Dynamics of Nanoelectronic Systems, Center for Free-Electron Laser Science, Hamburg — [2]Max Planck Institute for Solid State Research, Stuttgart

A time-resolving sub-Kelvin scanning tunneling microscope (STM) is used to manipulate atoms and build nanostructures such as atomic chains or arrays. We show that not only static but also dynamic properties of nanostructures can be controlled. We place magnetic atoms into close proximity of existing nanostructures. This modifies available spin relaxation pathways. The resulting variations in the spin relaxation times and spin polarization can be monitored by an all-electronic pump-probe technique [1]. In this way even weak spin coupling can be detected. A vector magnetic field provides additional control over the mixing of spin states without changing the atomic configuration of a nanostructure. For example, we compare the angular dependence of the spin anisotropy for individual Fe atoms and Fe in few-atom arrays. The combination of vector magnetic fields with atom manipulation provides a great deal of control over the behavior of atomic spins making it possible to study spin dynamics at atomic dimensions.

[1] S. Loth, M. Etzkorn, C. P. Lutz, D. M. Eigler, A. J. Heinrich, Science 329, 1628 (2010).

O 31.10 Tue 12:45 H33

Atomically assembled antiferromagnets — •Sebastian Loth — Max Planck Research Group-Dynamics of Nanoelectronic Systems, Center for Free-Electron Laser Science, Hamburg — Max Planck Institute for Solid State Research, Stuttgart

When atoms are placed into regular arrays their magnetic moments can interact and form long-range ordered magnetic states. In particular antiferromagnetic spin coupling creates a large variety of possible collective states. We use low-temperature scanning tunneling microscopy to construct few-atom antiferromagnets. Their shapes can be defined precisely by atom manipulation. In this way uncompensated magnetic moments at the nanoparticle's edge can be avoided. We use such spin-compensated atomic arrays to study the intrinsic dynamics of nanoscale antiferromagnets [1]. For two-dimensional arrays of growing size we can trace the transition from the quantum mechanical singlet ground state to doubly degenerate Neel-type states. Arrays with ten or more atoms can be stable in each state for several hours but current-induced switching between the metastable spin states proceeds at nanosecond speed. These properties enable a model demonstration of dense magnetic data storage using antiferromagnets memory elements.

[1] S. Loth, S. Baumann, C. P. Lutz, D. M. Eigler, A. J. Heinrich, Science 335, 196 (2012).

O 31.11 Tue 13:00 H33

Epitactical grown Kondo lattices spanning different localization regimes of the Ce 4f electrons — •Holger Schwab, Mattia Mulazzi, and Friedrich Reinert — Physikalisches Institut, Experimentelle Physik VII, Universität Würzburg, D-97074 Würzburg, Germany

Ce surface alloys promise to be the choice of materials to study transformations of the electronic band structure during low temperature phase transitions in Kondo lattices. [1] The low temperature behaviour of Ce based Kondo systems strongly depends on the energy scales in the Ce atom and the hybridization between the Ce 4f orbitals and the conduction band. [2] Probing the Ce 4f spectral function [3] or the Ce 3d states therefore allows to preliminarily characterize and select such compounds. With XPS (X-ray Photoelectron Spectroscopy) of the Ce 3d states we investigated Ce surface alloys on Ag(111), Pt(111) and Pd(111) surfaces. Based on a GS-fit [4] to these data we were able to compare and rank the parameters responsible for the behaviour of these alloys in the single impurity regime of the Kondo lattice.

[1] M. Klein et al.,Phys. Rev. Lett. 106, 186407 (2011), P. Coleman, Science 327, 969 (2010)
[2] F. Patthey et al., Phys. Rev. B 42, 8864 (1990)
[3] H. Schwab et al., Phys. Rev. B 85, 125130 (2012)
[4] O. Gunnarsson et al., Phys. Rev. B 28, 4315 (1983)