O 32: Surface Magnetism and Spin Phenomena

Time: Tuesday 18:15–21:00 Location: Poster A

O 32.1 Tue 18:15 Poster A

Single molecule spintronics with spin carriers of 2p, 3d or 4f electrons — •yajie zhang and kai wu — College of Chemistry and Molecular Engineering, Peking University, Beijing, China

A revolution in electronics is with the contemporary evolution of the two novel disciplines of spintronics and molecular electronics. A fundamental link between these two fields can be established using organic magnetic materials. Using a low-temperature scanning tunneling microscopy (STM) and scanning tunneling spectroscopy (STS), we are able to study the single molecules under ultrahigh vacuum conditions at 4.2 /0.4 K. In this talk, we measured the magnetic properties of retinoic acid molecules, FePc and DyPc2 adsorbed on metal surface with corresponding spin carries of 2s, 3p, and 4f electrons. Unlike the pre-existing metal ion in FePc or DyPc2, retinoic acid molecules can be switched reversibly to a special state by placing the tip over the neck of the bulky heads at an appropriate sample voltage. The generation of a stable cationic radical makes the molecule have an unpaired electron. The dI/dV spectrum confirms the appearance of spin in switched states. In addition, we proposed that the two Pc ligands in the same double-decker DyPc2 molecules molecule rotate by 45 degrees against each other, which can be directly deduced from the STM imaging.

O 32.2 Tue 18:15 Poster A

Spin-resolved electron transmission through chiral films on metal surfaces — •Matthias Kettner[1], Benjamin Göhler[1], Debabrata Mishra[2], Georg F. Hanne[2], Ron Naaman[2], and Helmut Zacharias[1] — [1]Physikalisches Institut, Universität Münster, Germany — [2]Department of Chemical Physics, Weizmann Institute, Rehovot, Isreal

The increasing interest in sources for spin polarized electrons for spintronic applications leads to new approaches, including interaction of electrons with chiral molecules. Experiments on self-assembled monolayers of DNA indicated a spin-filtering behavior of the molecules [1]. In our experiments the samples, kept at room temperature, are irradiated with 213nm laser radiation to generate photoelectrons from metal substrates covered with various chiral thin films. These electrons transmit the chiral film and are analyzed by a Mott polarimeter. It can be shown that due to the interaction of the photoelectrons within the films electrons are spin-filtered. Longitudinal spin polarizations up to 57% can be measured in case of double stranded DNA even by irradiation with linearly polarized light [2]. Experiments with other chiral molecules, namely membrane proteins and self-assembled monolayers of α-helical polypeptides show similar electron spin filtering properties [3]. Furthermore a dependence of the spin polarization on the length of the molecules is measured.

[1] S.G. Ray et al., PRL 96, 036101 (2006)
[2] B. Göhler et al., Science 331, 894 (2011)
[3] D. Mishra et al., PNAS 110, 14872 (2013)

O 32.3 Tue 18:15 Poster A

Spin-polarized surface electronic structure of Ta(110) and W(110): Similar, yet different — •Bernd Engelkamp[1], Hossein Mirhosseini[2], Henry Wortelen[1], Anke Schmidt[1], Jürgen Henk[3], and Markus Donath[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany — [2]Institut für Anorganische Chemie und Analytische Chemie, 55122 Mainz, Germany — [3]Institut für Physik, Martin Luther-Universität Halle-Wittenberg, 06120 Halle, Germany

For Ta(110) and W(110), a very similar surface electronic structure is expected. One remarkable feature on W(110) is a spin-polarized, Dirac-cone-like occupied surface state with a spin texture, which is reminiscent of topological surface states [1], [2]. Due to the lack of one electron in tantalum compared with tungsten this surface state is expected above the Fermi level for Ta(110).

In this poster, we present a spin- and angle-resolved inverse photoemission study of Ta(110) in combination with spectral-density calculations. Surprisingly, we could not identify a Dirac-cone-like surface state on Ta(110), but instead a spin-split unoccupied surface state. The similarities and differences between the surface electronic structure of W(110) and Ta(110) will be discussed.

[1] K Miyamoto *et al.* Phys. Rev. Lett. **108**, 066808 (2012)
[2] H Mirhosseini *et al.* New J. Phys. **15**, 033019 (2013)

O 32.4 Tue 18:15 Poster A

Construction and realization of a 1K spin-polarized scanning tunneling microscope operable in a high magnetic field — Andreas Sonntag[1], Jan Hermenau[1], •Nadine Hauptmann[2], and Alexander Ako Khajetoorians[1,2] — [1]Institute of Applied Physics, Jungiusstrasse 9A, 20355 Hamburg, Germany. — [2]Institute for Molecules and Materials, Radboud Universiteit, 6500 GL Nijmegen, The Netherlands

Low-temperature scanning probe microscopy is a powerful method to explore the means of atomic-scale magnetism. In particular, this method has the potential of studying non-collinear magnetic structures on the cutting edge of magnetic material research, such as skyrmions [1], which are promising candidates for future application in data-storing and information-processing devices [2]. We present the design and setup of a home-built scanning tunneling microscope working at 1K based on a JT-stage with 4He, operating in a 9T out-of-plane magnetic field. The system is optimized for long hold times (~7 days), and capable of spin-polarized measurements based on a robust tip/sample exchange mechanism. Additionally, the system features two additional chambers for preparation of magnetic material on both tip and sample.

[1] S. Heinze, K. von Bergmann, M. Menzel, J. Brede, A. Kubetzka, et al., Nature Phys. 7, 713 (2011). [2] J. Sampaio, V. Cros, S. Rohart, A. Thiaville, and A. Fert, Nature Nanotech., 8, 839 (2013).

O 32.5 Tue 18:15 Poster A

Tuning the Magnetic Anisotropy and the Coupling to the Surface in Fe-Octaethylporphyrin-Cl Complexes on Au(111) — •Olof Peters, Benjamin W. Heinrich, Xianwen Chen, Christian Lotze, and Katharina J. Franke — Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Magnetism in single transition metal atoms is determined by small details in their atomic scale environment. Variations in the ligand field of metal organic complexes can change the molecule's spin state and its zero field splitting. Here, we report the controllable manipulation of a molecule's spin state and magnetic anisotropy by changing its ligand field with the tip of a scanning tunneling microscope.

As a model system we use Fe-octaethylporphyrin-Cl (FeOEP-Cl) complexes adsorbed on a Au(111) surface to study the influences of a Au tip approaching to the molecule's Fe center. Via inelastic electron tunneling spectroscopy we probe spin excitations and observe an increase in the zero-field splitting as the tip-molecule distance decreases. In addition a signature of Kondo screening appears, indicating a different coupling of the molecule to the surface. B-field dependent measurements reveal the expected splitting of the Kondo resonance. We ascribe our results to a modification of the crystal field leading to a shift in the d-level energies.

O 32.6 Tue 18:15 Poster A

Surface states on Fe(110) - exploring their spin, decay rates, and magnetic linear dichroism — Beatrice Andres, •Marko Wietstruk, and Martin Weinelt — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

Investigating iron (Fe) may seem old-fashioned but still it exhibits an exotic electronic band structure regarding it's spin dependence. The large exchange splitting combined with hybridization of *s*, *p*, and *d* states results in totally different conditions for the formation of majority and minority surface-states [1]. In contrast to the well-known bulk band structure, very few studies on surface states have been performed. Some show quasiparticle renormalization in the surface states due to electron-magnon coupling [2,3].

We study the surface band structure on Fe/W(110) in a spin- and time-resolved one- and two-photon-photoemission experiment. On the one hand, we directly probe the occupied electronic structure with the fourth harmonic (6 eV) of a Ti:Sa laser. On the other hand, we use the fundamental (1.65 eV) and third harmonic (5 eV) to probe unoccupied image-potential states and investigate their spin-dependent decay rates. We find two occupied minority surface features crossing the Fermi level at $\approx 0.1\,\text{Å}^{-1}$ in $\overline{\Gamma}$-$\overline{\text{H}}$ direction. These two minority features show a magnetic-linear-dichroic contrast (MLD) of opposite sign indicating different symmetries.

[1] Jürgen Braun, *Phys. Rev. B* **65**, 184412 (2002)

[2] Jörg Schäfer, *Phys. Rev. Lett.* **92**, 097205 (2004)
[3] Jörg Schäfer, *Phys. Rev. B* **72**, 155115 (2005)

O 32.7 Tue 18:15 Poster A

Tunneling processes into localized subgap states in superconductors — •Michael Ruby[1], Falko Pientka[1,2], Yang Peng[1,2], Benjamin W. Heinrich[1], Felix v. Oppen[1,2], and Katharina J. Franke[1] — [1]Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

The Yu-Shiba-Rusinov states bound by magnetic impurities in conventional s-wave superconductors are a simple model system for probing the competition between superconducting and magnetic correlations. Shiba states can be observed in scanning tunneling spectroscopy (STS) as a pair of resonances at positive and negative bias voltages in the superconducting gap. These resonances have been interpreted in terms of single-electron tunneling into the localized sub-gap states. This requires relaxation mechanisms that depopulate the state after an initial tunneling event. Recently, theory suggests that the current can also be carried by Andreev processes which resonantly transfer a Cooper pair into the superconductor.

We performed high-resolution STS experiments on single adatom Shiba states on the superconductor Pb, and provide evidence for the existence of two transport regimes. The single-electron processes dominate at large tip-sample distances and small tunneling currents, whereas Andreev processes become important at stronger tunneling. Our conclusions are based on a careful comparison of experiment and theory.

O 32.8 Tue 18:15 Poster A

The magnetic properties of $\mathbf{CoH}_n$ complexes on *h*-BN/Rh(111) — •Matthias Muenks[1], Peter Jacobson[1], Tobias Herden[1], Gennadii Laskin[1], Oleg Brovko[2], Markus Ternes[1], and Klaus Kern[1,3] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]Max Planck Institute of Microstructure Physics, Halle, Germany — [3]École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Transition metal adatoms on decoupling layers, such as *h*-BN/Rh(111), have peaked interest because they provide a testbed for magnetic properties at the single atomic scale. Intriguing features such as a high magnetic anisotropy of Co adatoms on MgO [1] or the controlled ionization of Co adatoms on graphene [2] are among these exciting results. Here we use a combined STM/AFM working at 1.2 K and magnetic fields up to 14 T to investigate CoH_n complexes that adsorb on the highly corrugated *h*-BN/Rh(111) Moiré [3] [4]. We found that CoH_2 shows a Kondo resonance characteristic for a spin-1/2 system, whereas CoH molecules have a clear spin-1 signature. For these spin-1 systems we present experimental proof of the correlation between the magnetic anisotropy energy and the coupling strength to the substrate. The result is supported by theoretical calculations.

[1] I. G. Rau *et al.*, Science 344 (6187), pp. 988-992 (2014) [2] V. W. Brar *et al.*, Nature Physics 7 , pp. 43-47 (2011) [3] T. Herden *et al.*, Nano Letters 14 (6), pp. 3623-3627 (2014) [4] F. D. Natterer *et al.*, PRL 109, pp. 066101 (2012)