O 81: Poster Session VI: Poster to Mini-Symposium: Manipulation and control of spins on functional surfaces II

Time: Wednesday 13:30–15:30 Location: P

O 81.1 Wed 13:30 P

Spin polarization of quantum confined surfaces states of 2D metal-organic network structures — •Lu Lyu, Tobias Eul, Wei Yao, Benito Arnoldi, Benjamin Stadtmüller, and Martin Aeschlimann — Department of Physics, TU Kaiserslautern, Germany

Controlling the quantum confinement of spin-dependent electronic states by design of two-dimensional (2D) metal-organic networks (MON) opens a unique avenue to accelerate the implementation of quantum technology into the next generation of spintronic applications. In our work, we focus on the quantum confinement of occupied Shockley surface states (SS) and unoccupied image potential states (IPS) of noble metal (111) surfaces by the formation of 2D metal-organic networks. Both surface states are well-known quasi-free 2D electron gases (2DEGs) with a Rashba spin-orbit splitting. For the exemplary case of the Cu-T4PT network on Cu(111) surface, we investigate the trapping of the 2DEG into a 2D quantum dot system using spin- and momentum-resolved photoemission. We reveal that the dispersion free electron-like surface states transform into periodic bands in momentum space. The details of the band structure depend critically on the intercoupling between electrons trapped in neighboring pores. In addition, we demonstrate that the mixing of molecular and metallic states reduces the magnitude of the spin-splitting of confined SS and IPS due to the strongly reduced spin-orbit coupling strength of the molecular materials. Our works open up a new avenue towards manipulating the spin-dependent trapping of electrons in metal-organic network structures.

O 81.2 Wed 13:30 P

A scanning tunneling microscope capable of electron spin resonance and pump-probe spectroscopy at mK temperature and in vector magnetic field — •Werner M.J. van Weerdenburg[1], Manuel Steinbrecher[1], Niels P.E. van Mullekom[1], Jan W. Gerritsen[1], Henning von Allwörden[1], Fabian D. Natterer[2], and Alexander A. Khajetoorians[1] — [1]Institute for Molecules and Materials, Radboud University Nijmegen, the Netherlands — [2]Department of Physics, University of Zürich, Switzerland

Recent advances in detecting atomic spin dynamics have combined techniques like electron spin resonance (ESR) and pump-probe spectroscopy with scanning tunneling microscopy (STM). Such methods have been employed to detect small magnetic interactions, and spin relaxation and coherence times in the nanosecond regime.

Here, we demonstrate the implementation of ESR and all-electrical pump-probe spectroscopy in a dilution-refridgerator (DR) STM, equipped with a vector magnetic field [1]. The efficient cooling of the DR permits the use of appreciable RF amplitudes at the STM junction while remaining at mK base temperature. We measure ESR resonances of a single TiH molecule on MgO/Ag(100) in an unprecedented low frequency band [2], enabled by the mK temperature, and use pump-probe spectroscopy to study the spin relaxation time of single Fe atoms on MgO/Ag(100) in a vector magnetic field.

[1] W. van Weerdenburg et al., arXiv:2007.01835v2;
[2] M. Steinbrecher et al., arXiv:2007.01928

O 81.3 Wed 13:30 P

Experimental connection between Yu-Shiba-Rusinov states and the Kondo effect using numerical renormalization group theory — •Haonan Huang[1], Sujoy Karan[1], Robert Drost[1], Ciprian Padurariu[2], Alfredo Levy Yeyati[3], Juan Carlos Cuevas[3], Björn Kubala[2], Joachim Ankerhold[2], Klaus Kern[1,4], and Christian R. Ast[1] — [1]MPI für Festkörperforschung, Stuttgart, Germany — [2]Institut für Komplexe Quantensysteme and IQST, Universität Ulm, Ulm, Germany — [3]IFIMAC, Universidad Autónoma de Madrid, Madrid, Spain — [4]EPFL, Lausanne, Switzerland

Magnetic impurities on superconductors give rise to Yu-Shiba-Rusinov (YSR) states in the gap. When the superconductivity is quenched, the Kondo effect manifests itself as a spectral anomaly at the Fermi energy. Both phenomena can be understood quantitatively with the single impurity Anderson model (SIAM) using numerical renormalization group (NRG) theory. One prediction of this theory is that the YSR energy depends universally on the ratio between the Kondo temperature T_K and the superconducting order parameter Δ. Nevertheless, deviations from this universal behavior have been observed in different experiments. Using a scanning tunneling miscroscope, we show that for a spin 1/2 impurity on the apex of a superconducting vanadium tip, both the YSR state and the Kondo peak can be quantitatively reproduced by the NRG theory using the Ljubljana code. Intriguingly, the asymmetry of the experimental spectra is also contained within the SIAM for both cases, indicating the essential role of the particle-hole asymmetry which is absent in the conventional Kondo impurity model.

O 81.4 Wed 13:30 P

Engineering atomic-scale magnetic fields by dysprosium single atom magnets — •Aparajita Singha[1,2,3], Philip Willke[1,2,4], Tobias Bilgeri[5], Xue Zhang[1,2], Harald Brune[5], Fabio Donati[1,2], Andreas Heinrich[1,2], and Taeyoung Choi[1,2] — [1]Center for Quantum Nanoscience, Institute for Basic Science (IBS), Republic of Korea — [2]Ewha Womans University, Republic of Korea — [3]Max-Planck-Institut für Festkörperforschung, Germany — [4]Physikalisches Institut, KIT, Germany — [5]Institute of Physics, EPFL, Switzerland

Atomic-scale engineering of magnetic fields is a key ingredient for miniaturizing quantum devices and precision control of quantum systems. This requires a unique combination of magnetic stability and spin-manipulation capabilities. Surface-supported single atom magnets [1,2] offer such possibilities, where long temporal and thermal stability of the magnetic states can be achieved by maximizing the magnetic anisotropy and by minimizing quantum tunnelling of the magnetization. Here, we show that dysprosium atoms adsorbed on magnesium oxide have a giant anisotropy of 250 meV, currently the highest among all surface spins. Using a variety of STM techniques including single atom electron spin resonance [3], we confirm no spontaneous spin-switching in these atoms over days at ≈ 1 K under low and even at vanishing magnetic fields. We utilize these robust single atom magnets to engineer magnetic nanostructures, demonstrating unique control of magnetic fields with atomic-scale tunability. [1] Science 352, 318 (2016); [2] Nature 543, 226 (2017); [3] Science 350, 417 (2015).

O 81.5 Wed 13:30 P

An ultra-high vacuum electron spin resonance spectrometer for investigation of magnetic atoms and molecules at surfaces — •Jisoo Yu[1,2], Franklin Cho[1,2], Luciano Colazzo[1,2], Yejin Jeong[1,2], Junjie Liu[3], Arzhang Ardavan[3], Giovanni Boero[4], Andreas Heinrich[1,2], and Fabio Donati[1,2] — [1]Center for Quantum Nanoscience (QNS), Insititute for Basic Science (IBS), Seoul, Republic of Korea — [2]Department of Physics, Ewha Womans Universitiy, Seoul, Republic of Korea — [3]The Clarendon Laboratory, Department of Physics, University of Oxford, Oxford, UK — [4]Ecole Polytechnique Fédérale de Lausanne (EPFL), Laboratory for Microsystems, Lausanne, Switzerland

Magnetic atoms and molecules on surfaces are model systems to control and manipulate quantum coherence properties at the smallest scale of matter. Their performances as qubits can be investigated through electron spin resonance (ESR) spectroscopy [Nat. Chem. 11, 301(2019)]. However, commercial spectrometers do not meet the requirements of ultra-high vacuum (UHV) and surface-sensitivity to measure a single layer of surface-adsorbed spin centers. We present an UHV ESR spectrometer that enables us to measure thin molecular films in a wide range of temperature (2.5-300 K) and magnetic field (0-3.2 T). This spectrometer operates in the X-band (10 GHz) both in continuous wave (CW) and pulsed mode. To maximize the microwave field on a 2D spin system we deposited the molecular layer directly on the resonator surface. We demonstrate sensitivity of 10^{12} spins/G*Hz in CW, which allows ESR measurements down to a single layer of molecular spins.

O 81.6 Wed 13:30 P

Quantifying the interplay between fine structure and geometry of an individual molecule on a surface — •Manuel Steinbrecher[1], Werner M.J. v. Weerdenburg[1], Etienne F. Walraven[1], Niels P.E. v. Mullekom[1], Jan W. Gerritsen[1], Fabian D. Natterer[2], Danis I. Badrtdinov[3,1], Alexander N. Rudenko[4,3,1], Vladimir V. Mazurenko[3], Mikhail I.

Katsnelson[1,3], Ad v.d. Avoird[1], Gerrit C. Groenenboom[1], and Alexander A. Khajetoorians[1] — [1]Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands — [2]Department of Physics, University of Zurich, Zurich, Switzerland — [3]Theoretical Physics and Applied Mathematics Department, Ural Federal University, Ekaterinburg, Russia — [4]School of Physics and Technology, Wuhan University, Wuhan, China

With spin-resolved scanning tunneling microscopy (SP-STM) and electron spin resonance (ESR) we have probed single TiH molecules deposited on a thin insulating MgO layer in a vector magnetic field at mK temperatures down to MHz frequencies. We find that the molecule retains a non-trivial orbital angular momentum. This results in a strongly renormalized and anisotropic g-tensor. As we prove, the latter does not stem from Kondo or Jahn-Teller effects. From quantum chemistry embedded cluster calculations we find an analytical expression for the g-tensor, which solely depends on the splitting of the ground states and the spin-orbit coupling. In a dynamic expansion of the model, the position of the H atom and rotational dynamics of the molecule were investigated. [1] Steinbrecher *et al.*, arXiv 2007.01928 (2020)

O 81.7 Wed 13:30 P

Inducing and Controlling Molecular Magnetism through Supramolecular Manipulation — •Jan Homberg, Alexander Weismann, Richard Berndt, and Manuel Gruber — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24118 Kiel, Germany

Diamagnetic H_2 phthalocyanine molecules are probed on superconducting Pb(100) using a low-temperature scanning tunneling micoscope (STM). In supramolecular arrays made with the STM, the molecules acquire a spin as detected *via* the emergence of Yu-Shiba-Rusinov resonances. The spin moments vary among the molecules and are determined by the electrostatic field that results from polar bonds in the surrounding Pc molecules. The moments are further finely tuned by repositioning the hydrogen atoms of the inner macrocycle of the surrounding molecules.