O 30: Surface Magnetism

Time: Tuesday 10:30–12:45 Location: H11

O 30.1 Tue 10:30 H11

Spin-polarized chiral edge modes in the topological nodal-point superconductor Mn/Ta(110) — •Felix Zahner[1], Felix Nickel[2], Roberto Lo Conte[3], Tim Drevelow[2], Roland Wiesendanger[1], Stefan Heinze[2], and Kirsten von Bergmann[1] — [1]University of Hamburg, Germany — [2]University of Kiel, Germany — [3]University of Groningen, The Netherlands

Topological superconducting phases in magnet-superconductor hybrid (MSH) - systems have been investigated recently due to their potential applications in quantum devices. Zero-energy states and chiral edge modes have previously been observed in ferromagnetic 1D [1] and 2D [2] MSH systems. In a 2D antiferromagnet (AFM) MSH and a spin spiral MSH system, gapless topological nodal-point superconducting (TNPSC) phases have been observed [3, 4].

Using scanning tunnelling microscopy/spectroscopy (STM/S), we investigate the mono- and bilayers on a Ta(110) surface. Both exhibit local AFM order and tight-binding calculations indicate that both host a TNPSC phase. Interestingly, we observe edge modes not only at the boundaries between the TNPSC and the topologically trivial superconducting substrate, but also at specific boundaries between these two AFM systems of Mn mono- and bilayer. Our spin-polarized STM measurements reveal a significant spin-polarization of this edge mode, which we discuss based on the tight-binding results.

[1] Nadj-Perge, S. et al., Science 346, 602 (2014). [2] Palacio-Morales, A. et al., Sci. Adv. 5, eaav6600 (2019). [3] Bazarnik, M. et al, Nat Commun 14, 614 (2023). [4] Brüning, R. et al., arXiv:2405.14673.

O 30.2 Tue 10:45 H11

Interaction of chiral molecules with magnetic substrates: An ongoing DFT puzzle — •Nicolae Atodiresei — Peter Grünberg Institute (PGI-1), Forschungszentrum Jülich, D-52425 Jülich

A challenging puzzle in surface science that has to be solved is the interplay between electron spin and molecular chirality. As an example, the interaction of chiral helical aromatic molecules with magnetic surfaces leads to an enantioselective adsorption, i.e. molecules of opposite handedness would preferentially adsorb to ferromagnetic islands with opposite magnetization [1]. In this talk, I will discuss how state-of-the-art spin-resolved *ab initio* simulations based on density functional theory calculations support and guide the interpretation of scanning tunneling microscopy experiments performed on the adsorption of heptahelicene molecule onto ferromagnetic cobalt islands.

The author acknowledges funding from CRC 1238 of the Deutsche Forschungsgemeinschaft and computing time granted on the supercomputer JURECA at Forschungszentrum Jülich.

[1] Mohammad Reza Safari et al., Adv. Mater. **36**, 2308666 (2024)

O 30.3 Tue 11:00 H11

Spin-lattice relaxation of nitrogen-vacancy centers in nanodiamonds on conducting and non-conducting surfaces — •Izidor Benedičič[1], Yuri Tanuma[1], Bastien Anézo[1,2], Žiga Gosar[1,3], and Denis Arčon[1,3] — [1]Department of Condensed Matter Physics, Jožef Stefan Institute, Ljubljana, Slovenia — [2]Institut des Matériaux de Nantes Jean Rouxel (IMN), Nantes University, Nantes, France — [3]Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia

Nitrogen-vacancy (NV) centers in diamond are versatile probes for the detection of both static magnetic fields and magnetic fluctuations. While single-NV sensors are very capable, they suffer from high cost and experimental complexity. Nanodiamonds with embedded NV ensembles offer a promising low-cost alternative, however, their application in solid-state physics has been largely overlooked. Here, we investigate the use of nanodiamonds for measuring the electrical conductivity of substrates. We measured the temperature dependence of longitudinal relaxation time T_1 of NV centres in nanodiamonds on glass and gold substrates. We find that T_1 is determined both by phononic relaxation processes and the coupling to the magnetic moments at the surface. All samples show a stretched exponential relaxation, hinting at a significant distribution of relaxation processes. The theoretical models show the intrinsic distribution is too wide to reliably detect coupling to electronic states even of very good conductors. Our results hint at the limitations of nanodiamonds for measurements of transport properties in condensed matter systems.

O 30.4 Tue 11:15 H11

Imaging in-plane magnetic domains using magnetic circular dichroism in darkfield laser PEEM — •David Huber[1], Friederike E. Wührl[1], Frank O. Schumann[2], and Wolf Widdra[1] — [1]Martin-Luther-Universität Halle-Wittenberg — [2]Max-Planck-Insitut für Mikrostrukturphyisk, Halle

Magnetic circular dichroism (MCD) in threshold photoelectron emission microscopy (PEEM) enables imaging of magnetic domains at the nanoscale. Utilizing femtosecond (fs) laser excitation in a laboratory setting offers a significant advantage in terms of temporal resolution compared to more commonly used X-ray MCD measurements. However, this poses new challenges with respect to in-plane magnetization, given the previously reported low domain contrast [1, 2].

In this contribution we show that symmetry breaking and photoelectron filtering in momentum and energy help to overcome these challenges. Using this methodology, we obtain MCD contrast for in-plane domains of 11 nm Fe(001)-(1 × 1)-O on MgO(001) using both continuous wave and fs laser excitation at normal incidence and compare these results to a Fe(001)-(1 × 1)-O single crystal in PEEM and μARPES.

[1] Marx et al., PRL **84**, 5888 (2000).
[2] Nakagawa et al. PRL **96**, 237402 (2006).

Invited Talk O 30.5 Tue 11:30 H11

Resonant molecular transitions in femtosecond second harmonic generation spectroscopy of Fe-porphyrin/Cu(001) — •Andrea Eschenlohr[1], Rui Shi[2], Jinghao Chen[1], Ping Zhou[1], Uwe Bovensiepen[1], Wolfgang Hübner[2], and Georg Lefkidis[2] — [1]Faculty of Physics and CENIDE, University Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany — [2]Department of Physics, RPTU, Box 3049, 67653 Kaiserslautern, Germany

Metal-organic molecular adsorbates on metallic surfaces are potential future materials for (spin-)electronics applications, provided that the molecule-substrate interaction can be analyzed and manipulated in a targeted manner. By combining interface-sensitive optical second harmonic generation (SHG) spectroscopy experiments and electronic structure calculations using coupled cluster methods including optical excitations on iron-octaethylporphyrin (FeOEP) adsorbed on Cu(001), we find that the SHG response of FeOEP/Cu(001) is modified at 2.15-2.35 eV fundamental photon energy compared to the bare Cu(001) surface. We conclude a resonantly enhanced SHG by molecular transitions, which results from a strong charge-transfer character of the molecule-substrate interaction [1]. Pump-probe SHG reveals a markedly slower relaxation time at this resonance, indicating an increased lifetime of the optically induced state compared to the bare Cu(001) surface, which will be discussed in the context of charge transfer dynamics.

[1] Eschenlohr et al., arXiv:2409.09801

O 30.6 Tue 12:00 H11

Single-layer magnetism of epitaxial NiBr2 and FeBr2 on NbSe2 — •Sebastien E. Hadjadj[1], Carmen Gonzalez-Orellana[2], Adriana Candia[3], Pierluigi Gargiani[4], Matthias Muntwiler[5], Jan Dreiser[5], Jorge Lobo[3], Celia Rogero[2], and Maxim Ilyn[2] — [1]Materials Physics Center (MPC), Donostia, Spain — [2]Centro de Fisica de Materiales (CSIC/UPV-EHU), Donostia-San Sebastian, Spain — [3]Instituto de Nanociencia y Materiales de Aragon (INMA),Zaragoza, Spain — [4]ALBA Synchrotron Light Source, Barcelona, Spain — [5]Paul Scherrer Institut, Villigen, Switzerland

Two-dimensional metal dihalides exhibit promising magnetic and electronic properties. Over the past years, the research focus on novel 2D magnetic materials has shifted to transition metal di-halides (TMDH). Recent reports have shown that the first layer of Br-based TMDH grown on Au(111) behaves structurally and magnetically differently from the second layer [1-2]. Here we report the first layer growth of NiBr2 and FeBr2 on NbSe2, which shows no signs of decomposition as observed for NiBr2 on Au(111) and shows unaffected stable magnetic properties ranging from monolayer to multilayer. The structural characterization of the samples revealed a strong temperature dependence in the resulting island growth and appearence of the moiré pattern. XMCD measurements probed magnetic ordering down to the 2D limit, which is in agreement with the literature values. In the case of FeBr2 a

strong reduction of the spin magnetic moment has been observed. [1] Djuro Bikaljevic et al., ACS Nano, 15, 14985, (2021) [2] S. E. Hadjadj et al., Chem. Mater., 35, 23, 9847-9856, (2023)

O 30.7 Tue 12:15 H11

Graphene intercalated Eu on magnetic surfaces a DFT study — •Gustav Bihlmayer[1], Polina M. Sheverdyaeva[2], Matteo Jugovac[3], Luisa Ferrari[4], Frederico Mazzola[5], Paolo Perna[6], Nicolae Atodiresei[1], and Stefan Blügel[1] — [1]Peter Grünberg Institute (PGI-1), Forschungszentrum Jülich, D-52425 Jülich — [2]CNR-ISM, 34149 Trieste, Italy — [3]Elettra Sincrotrone Trieste, 34149 Trieste, Italy — [4]CNR-ISM, 00133 Roma, Italy — [5]CNR-IOM, 34149 Trieste, Italy — [6]IMDEA Nanociencia, Campus de Cantoblanco, 28049, Madrid, Spain

Europium can be intercalated between graphene and magnetic surfaces like Co(0001) or Ni(111) forming a $\sqrt{3} \times \sqrt{3}$ layer [1]. The doping of graphene can create a pronounced flat band at the Fermi level and the interaction of the $4f$ states with the π band of graphene leads to spin-selective hybridization and opening of the Dirac cone with interesting consequences for edge channels [2]. This system can be compared to Eu on-top of a graphene covered Co substrate, that changes the magnetic coupling between the lanthanide and the substrate [3] and modifies the graphene's interaction with the $4f$ states. Further stacking combinations are possible and will be discussed [4].

We acknowledge funding from the FLAG-ERA grant SOgrapMEM and from CRC 1238 of the Deutsche Forschungsgemeinschaft.

[1] F. Huttmann et al., Phys. Rev. B **95**, 075427 (2017) [2] P. M. Sheverdyaeva et al., Phys. Rev. Lett. **132**, 266401 (2024) [3] M. Jugovac et al., Adv. Mater. **35**, 2301441 (2023) [4] M. Jugovac et al., Carbon **230**, 119666 (2024)

O 30.8 Tue 12:30 H11

Emergence of Ferromagnetism in 3d-4f Hetero-Bimetallic Surface-Architectures — •Massine Kelai[1], Serim Jeon[1], Dasom Choi[1], Corina Urdaniz[1], Pierre Josse[1], Jaehyun Lee[1], Stefano Reale[1], Yongwoo Kim[1], Weibin Li[2], Pierluigi Gargiani[2], Woo-Suk Noh[3], Dominik Lungerich[4], Christoph Wolf[1], Fabio Donati[1], and Lucinao Colazzo[1] — [1]Center for Quantum Nanoscience, Institute for Basic Science, Seoul, Republic of Korea — [2]ALBA Synchrotron Light Source, 08290 Catalonia, Spain — [3]MPPC/CPM, Max Planck POSTECH, Pohang 37673, Republic of Korea — [4]Center for Nanomedicine, Institute for Basic Science (IBS), 50 Yonsei-ro, Seodaemun-gu, 03722 Seoul, Republic of Korea

Surface-confined metal-organic coordination networks (SMONs) are emerging platforms for designing tunable low-dimensional nanostructures, with 3d-4f hetero-bimetallic systems being promising candidates for high-density memory and qubit applications. However, the mechanisms underlying their formation and magnetic interactions remain largely unexplored. Here, we investigate a novel 3d-4f SMON, Dy-FeTCPP (TCPP = 5,10,15,20-(tetra-4-cyanophenyl)porphyrin), formed on Au(111) via on-surface chemical reaction pathways. Using X-ray absorption spectroscopy, magnetic circular dichroism, scanning tunneling spectroscopy, and density functional theory, we show that lanthanide insertion induces strong substrate-mediated ferromagnetic coupling between 3d units, driven by porphyrin core deformation upon Dy-cyanophenyl bonding. This work advances the understanding of SMONs, paving the way for scalable quantum devices on surfaces.