O 64: Surface Magnetism

Time: Wednesday 15:00–17:45 Location: HSZ/0403

Invited Talk O 64.1 Wed 15:00 HSZ/0403

Cantilever based Scanning Force Microscopy: Ultimate Sensitivity and Quantitative Imaging of Nanoscale Spin Textures — •Hans J. Hug — Empa, Ueberlandstrasse 129, 8600 Dübendorf, Switzerland — Department of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel

Cantilever-based scanning force microscopy operated under vacuum or ultra-high-vacuum (UHV) conditions is a powerful and versatile technique for surface characterization with atomic resolution. Beyond topographic imaging, multimodal and multifrequency approaches enable the simultaneous mapping of Kelvin potential differences and magnetic stray fields with exceptional sensitivity. These advanced methodologies have been applied to quantitatively determine skyrmion diameters in both ferromagnetic and synthetic antiferromagnetic multilayers, revealing skyrmions with diameters down to 25 nm. Furthermore, local tip sample distance control allows MFM imaging on curved substrates, uncovering curvature-induced modifications of the Dzyaloshinskii*Moriya interaction. Finally, we demonstrate the capabilities of UHV multimodal scanning force microscopy by resolving the atomic-scale structure, local Kelvin potential, and magnetic stray fields of NiBr* monolayers grown on Au substrates, highlighting the potential of these techniques for exploring emergent magnetic phenomena in low-dimensional materials.

O 64.2 Wed 15:30 HSZ/0403

Intra-atomic s-f correlation in a single Sm atom probed by ESR-STM — Masahiro Haze[1], Saba Taherpour[2,3], Christoph Wolf[2,3], Jaehyun Lee[2,3], Yaowu Liu[2,3], Andreas Heinrich[2,3], Fabio Donati[2,3], •Yasuo Yoshida[4], and Soo-hyon Phark[2,3] — [1]ISSP Univ. Tokyo, Kashiwa, Japan — [2]Center for Quantum Nanoscience, Seoul, Korea — [3]Ewha Womans University, Seoul, Korea — [4]Kanazawa Univ, Kanazawa, Japan

Correlations between s- and f-electrons are a fundamental topic in condensed matter physics, as they can give rise to exotic phases such as heavy-fermion or non-Fermi-liquid states. Recent work has shown that isolated Sm atoms adsorbed on MgO adopt a monovalent configuration with an S=1/2 spin originating from the 6s orbital, making a single Sm atom an ideal platform for studying s-f correlations at the atomic level. Here, we performed ESR-STM measurements on individual Sm atoms adsorbed on MgO films grown on an Ag(100) substrate. We find that the excitation energy varies strongly with the orientation of the external magnetic field, even though STM probes an S=1/2 spin, which is in principle free from single-ion magnetic anisotropy. The extracted g-values from the ESR measurements range from 1.3 to 6.4. This pronounced anisotropy indicates strong coupling between the s- and f-electrons within a single Sm atom, suggesting that surface-adsorbed Sm atoms may serve as promising building blocks for artificial Kondo lattices.

O 64.3 Wed 15:45 HSZ/0403

Elliptical skyrmions in a hydrogenated Fe double-layer on Ir(110) — Timo Knispel[1], Vasily Tseplyaev[2,3], •Gustav Bihlmayer[2], Stefan Blügel[2,3], Thomas Michely[1], and Jeison Fischer[1] — [1]II. Physikalisches Institut, Universität zu Köln, D-50937 Köln — [2]Peter Grünberg Institute (PGI-1), Forschungszentrum Jülich, D-52425 Jülich — [3]Institut für Theoretische Physik, RWTH Aachen University, D-52074 Aachen

Spin-polarized scanning tunneling microscopy (SP-STM) experiments demonstrate that the magnetic ground state of two pseudomorphic Fe layers on Ir(110) is a Néel-type spin spiral with a unique sense of rotation. Employing density functional theory (DFT) calculations, we show that this spin-spiral is stabilized by frustrated exchange interactions, but the rotation direction is fixed by the Dzyaloshinskii-Moriya interaction [1]. Hydrogen adsorption on the 2Fe/Ir(110) surface significantly modifies the spin-spiral minimum, shifting it to a longer wavelength and causing it to flatten energetically out with increasing H coverage. Using DFT calculations, we can trace back this behavior to electron doping of the surface and atomistic spin-dynamics simulations show that it is possible to induce elliptic skyrmions with an external magnetic field. These spin-textures can also be observed using SP-STM with a perpendicular B-field [2].
We acknowledge funding from the CRC 1238 of the Deutsche Forschungsgemeinschaft.
[1] T. Knispel et al., Phys. Rev. B **111**, L020405 (2025)
[2] T. Knispel et al., Nano Lett. **25**, 14565 (2025)

O 64.4 Wed 16:00 HSZ/0403

Light-driven modulation of proximity-enhanced functionalities in hybrid nano-scale systems — •Mattia Benini[1,2], Umut Parlak[3], Jaka Strohsack[4], Andrea Droghetti[5], Tomaz Mertelj[4], Valentin Alek Dediu[2], and Mirko Cinchetti[1] — [1]Department of Physics, TU-Dortmund, Dortmund, Germany — [2]ISMN-CNR, Bologna, Italy — [3]Department of Physics, Univesity of Konstanz, Konstanz, Germany — [4]Jozef Stefan Institute, Ljubljana, Slovenia — [5]Universitá Ca' Foscari, Venezia, Italy

Recent research on Co thin films surface-hybridized with π-conjugated organic molecules demonstrated that interfacial p-d hybridization[1] leads to the establishment of an exotic magnetic configuration, called *Correlated Ferromagnetic Glass* (CFG). It features a glassy-like arrangement of the magnetization and vortex topological defects[2], a strongly enhanced coercivity, and an unexpected complex magnetization dynamics[3]. In this work, we demonstrate that the interface-driven magnetic properties can be actively controlled by optical means, using Co/C_{60} heterostructures as a prototypical system. By generating excitons in the molecular layer with resonant ultrashort light pulses, we achieve up to a 60% reduction of the magnetization precession frequency, ultimately due to a quenching of the interface-induced magnetic anisotropy[4]. References [1] Cinchetti, M. et al., Nat. Mater. 2017, 16 (5), 507*515. [2] Benini, M. et al., Nat Commun 2025, 16 (1), 5807. [3] Strohsack, J. et al., Science Advances 2025, 11 (31), eadw2243. [4] Benini, M. et al., Nat Commun 2025, 16 (1), 7297.

O 64.5 Wed 16:15 HSZ/0403

Layer-dependent magnetic and electronic properties of 2D vdW magnet $FeCl_2$ on Bi(111) — •Shigemi Terakawa[1], Jianqiang Liu[1], Hikaru Ishikawa[1], Ryota Inoue[1], Isamu Yamamoto[2], Amilcar Bedoya-Pinto[3], Niels B. M. Schröter[4], and Kazuyuki Sakamoto[1] — [1]Department of Applied Physics, The University of Osaka, Osaka, Japan — [2]Synchrotron Light Application Center, Saga University, Saga, Japan — [3]Institute of Molecular Science, University of Valencia, Paterna, Spain — [4]Max Planck Institute of Microstructure Physics, Halle, Germany

Two-dimensional (2D) van der Waals (vdW) magnets are promising for future spintronic applications. Recently, transition metal dihalides (TMDHs) have received increasing attention as a new class of 2D vdW magnets. In this study, we report the layer dependence of the magnetic and electronic properties of ultrathin $FeCl_2$, a layered antiferromagnetic insulator, films on Bi(111) from monolayer to four layers. X-ray magnetic circular dichroism (XMCD) measurements revealed that the monolayer film exhibits an in-plane easy axis, while the thicker films have an out-of-plane easy axis with a spin-flip transition, which is consistent with the antiferromagnetic order of bulk $FeCl_2$. The transition field increases with increasing thickness. Angle-resolved photoelectron spectroscopy (ARPES) revealed insulating electronic structure irrespective of the thickness. Layer-dependent change is found as the increase in the width of the bands with large Cl 3p contributions. These results show that both the magnetic and electronic coupling through the vdW interfaces become stronger as the thickness increases.

Invited Talk O 64.6 Wed 16:30 HSZ/0403

Single-spin sensing: A molecule-on-tip approach — •Laurent Limot — Université de Strasbourg, CNRS, IPCMS, UMR 7504, F-67000 Strasbourg, France

Magnetometry plays a pivotal role in advancing ultra-dense data-storage technologies and addressing the challenges that arise as spin qubits are downscaled. A promising route toward atomic-scale single-spin sensing is the use of a magnetic molecule as a spin sensor, although practical implementations of this concept remain at an early stage. To demonstrate its feasibility and potential, we combine a nickelocene molecule with scanning tunneling microscopy to achieve versatile, spin-sensitive imaging of magnetic surfaces.

We investigate model Co islands of varying thickness on Cu(111), which exhibit distinct magnetic properties. Our approach proves robust and reproducible, offering atomic-scale sensitivity to both spin

polarization and magnetization orientation through the direct exchange coupling between the nickelocene-terminated tip and the Co surface. This capability enables the acquisition of magnetic exchange maps, whose characteristic magnetic corrugation patterns show excellent agreement with computed spin-density distributions. Building on this foundation, we will apply the method to probe the influence of hydrogen on magnetization, a topic of significant relevance in spintronics. Collectively, these advances substantially enhance our ability to probe and visualize magnetism at the atomic scale.

O 64.7 Wed 17:00 HSZ/0403

Tailoring Robust 1D Atomic and Electronic Textures in Mn Ultrathin Films on Fe(110) via Antiferromagnet-Ferromagnet Interfaces — •Toyo Kazu Yamada[1,2], Eiichi Inami[3], and Peter Krueger[1,2] — [1]Dept. Materials Science, Chiba Univ., Chiba, Japan — [2]Molecular Chirality Res. Centre, Chiba Univ., Chiba, Japan — [3]School of Systems Engineering, Kochi Univ. Tech., Kochi, Japan

Controlling the dimensionality of electronic states on two-dimensional (2D) surfaces has remained a significant challenge over decades. In particular, achieving one-dimensional (1D) electronic ordering on 2D surface could enable anisotropic quantum transport and support quantum-confined functional units for nanoscale device integration. In this study, we demonstrate that even conventional 3d transition metals, ferromagnetic (FM) Fe and antiferromagnetic (AFM) Mn, can give rise to 1D atomic stripe patterns in the local density of states (LDOS) on a 2D surface. This study investigates the emergence of one-dimensional (1D) atomic and electronic ordering in ultrathin manganese (Mn) films grown on atomically flat Fe(110) substrates. By combining scanning tunneling microscopy/spectroscopy (STM/STS) and density functional theory (DFT), we demonstrate that the interplay between antiferromagnetic and ferromagnetic interactions at the interface leads to robust 1D stripe electronic textures that remain stable even at room temperature, persisting in the presence of atomic-scale defects.

O 64.8 Wed 17:15 HSZ/0403

Influence of the light polarization on magnetic dichroism in threshold photoemission — •Frank O. Schumann[1] and Jürgen Henk[2] — [1]Max-Planck Institut für Mikrostrukturphysik, Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany

Incoming normal incidence light which is neither purely s- or p-polarized will become in general elliptically polarized inside a metallic surface. We ask how the magnetic dichroism is affected if the incoming light is changed from circularly to linearly polarized, with equally large s- and p-components. This is further compared if the incoming elliptically polarized light is tuned such that it becomes circularly polarized inside the surface. Initial theoretical work on normal emission demonstrated for in-plane magnetized samples a sizeable difference in the dichroism spectra for different light polarizations.[1]

We performed an one-step photoemission calculation for threshold photoemission from a Fe(100) and capture the emission into the full half sphere. The photon energy was 5.2 eV and the angle of incidence was set to 65° as realized in PEEM instruments. We are interested in domain imaging and we determine the relevant asymmetry for magnetic domains.[2] The spectra for a given magnetization direction and polarization state are very different whereas the magnetic dichroism signal displays a weak dependence.

[1] J. Henk and R. Feder, Phys. Rev. B **55**, 11476 (1997) [2] M. Paleschke et al., Phys. Rev. B **112**, 054411 (2025).

O 64.9 Wed 17:30 HSZ/0403

Triple-Q state in magnetic breathing kagome lattice — Hangyu Zhou[1,2], Manuel dos Santos Dias[3], Weisheng Zhao[1], and •Samir Lounis[4,2] — [1]Fert Beijing Institute, Beihang University, Beijing, China — [2]Peter Grünberg Institut, Forschungszentrum Jülich & JARA, Jülich, Germany — [3]Scienti c Computing Department, STFC Daresbury Laboratory, Warrington, United Kingdom — [4]Institute of Physics, Martin-Luther-University Halle-Wittenberg, Halle, Germany

Magnetic frustration in two-dimensional triangular spin lattices produces a variety of exotic states, from multi-Q configurations to disordered spin glasses. The antiferromagnetic kagome lattice, built from corner-sharing triangles, is a paradigmatic frustrated system with macroscopic degeneracy. Building on the kagomerization mechanism we recently introduced [1], we examine the magnetic breathing kagome lattice formed by an Mn monolayer on a heavy-metal substrate capped with h-BN [2]. The Mn kagome geometry induces strong frustration, reflected in the nearly flat bands obtained from spin-spiral energy calculations. Including further-neighbor interactions yields a spin-spiral energy minimum along Γ-K and a triple-Q state with nonzero topological charge, potentially causing highly nonlinear Hall responses. The flat-band character can also stabilize more complex spin textures featuring multiple Q-pockets in the spin structure factor. These findings provide a fertile platform for studying multi-Q states and emergent topological phenomena. [1] Zhou et al., Nature Communications 15, 4854 (2025); [2] Zhou et al., npj Spintronics 3, 31 (2025)