MA 32: Scanning Probe Microsocopy and Spin Phenomena

Time: Wednesday 15:00–17:00 Location: H4

Invited Talk MA 32.1 Wed 15:00 H4

Spin-orbit coupling, magnetic perturbations, and competing trends in topological insulators — •Matthias Bode — Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

Topological insulators (TIs) interacting with magnetic perturbations lead to several unconventional effects, usually described within the framework of gapping the Dirac quasiparticles due to broken time-reversal symmetry [1,2]. While the quantum anomalous Hall effect confirmes the presence of ferromagnetically gapped Dirac states, the overwhelming majority of photoemission and tunneling data demonstrate the presence of a finite density of states at the Dirac point even once the system becomes magnetic. We present a series of experiments which, by mapping the response of TIs to different magnetic impurities down to the atomic level, provide a detailed microscopic picture and thereby solve these contradictory observations in both surface- and bulk-doped samples. We provide evidence of highly anisotropic Dirac fermion-meditated magnetic interactions that lead to quantum coherent states propagating over mesoscopic distances. We also show that magnetic order and gapless states can coexist due to the emergence of a two-fluid behavior where the competition in between opposite trends, i.e. gap-opening vs. gap-closing, is ultimately linked to the localized vs. delocalized nature of the perturbations-induced quasiparticles.

[1] P. Sessi et al., Phys. Rev. B 88, 161407 (2013).

[2] P. Sessi et al., Nature Comm. 5, 5349 (2014).

Invited Talk MA 32.2 Wed 15:30 H4

Conductance and shot noise spectroscopy of single magnetic atoms and molecules — •Alexander Weismann — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel

The scanning tunneling microscope allows to build and study nanostructures at a single atom level. It can be further used to explore the ballistic electron transport regime by bringing the tip into contact with single atoms and molecules in a well-defined way. The measurement of quantum shot noise in nanoscopic contacts provides additional information on the underlying conduction processes and reveals a spin polarization of the current by single Fe and Co atoms between two gold electrodes. The impact of spin-orbit coupling on electron transport is demonstrated using single Ir atoms on a ferromagnetic substrate, where large changes of the anisotropic magnetoresistance occur between the tunneling and the contact regime. On retinoic acid, a closed-shell organic bio-molecules comprising only C, H and O atoms, the STM can be used to reversibly switch the spin state, which is attributed to the conversion into a radical cation.

Invited Talk MA 32.3 Wed 16:00 H4

Manipulating spins in single molecules on a superconductor — •Benjamin W. Heinrich — Freie Universität Berlin, Fachbereich Physik, Berlin

The dominant relaxation mechanism for excited spin states on a metal is the exchange of energy and angular momentum with conduction electrons, which results in the creation of electron-hole pairs. A commune strategy to increase the spin lifetime consists in reducing the exchange scattering by the introduction of a thin insulating layer between adsorbate and substrate. We propose an alternative route to stabilize excited spin states, which is based on combining a metal-organic complex with a type I superconductor. The organic ligand decreases the exchange scattering with the superconducting quasiparticles sufficiently to avoid screening. In turn, the superconducting gap prohibits the energy transfer to electron-hole pairs when the excitation energy is smaller than the gap. This increases the excitation lifetime for Fe-octaethylporphyrin-chloride to 10 ns when adsorbed on a superconducting lead substrate, which is orders of magnitude longer than when adsorbed on a metal.

Our strategy will enable even longer lifetimes, perhaps sufficiently long to enable coherent spin manipulation, for systems with a well-chosen anisotropy barrier. It turns out that metal-organic complexes might be suited to achieve this goal. They provide structural flexibility such that the ligand field can be reversibly modified by local potentials, *e.g.*, the tip of the STM, which then modifies the magnetic anisotropy. Fine-tuning of the anisotropy appears to be within reach.

MA 32.4 Wed 16:30 H4

Voltage-dependent rotational motion of Phthalocyanine molecules — •Andreas Krönlein, Jens Kügel, Paolo Sessi, and Matthias Bode — Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, 97074 Würzburg, Germany

Single particle manipulation offers unique possibilities to tune the electronic properties of molecular and atomic assemblies and thereby opens new pathways for future electronic devices. Therefore, the understanding of the underlying physical mechanisms is of significant importance. We have performed STM/STS measurements of single transition metal phthalocyanine (*TM*Pcs) molecules adsorbed on van der Waals surfaces. We find a voltage-dependent rotational movement threshold which coincidence with the energy of the lowest unoccupied molecular orbital (LUMO) [1] of the investigated molecules as determined by STS. Spatially resolved measurements reveal a good match between the spatial distribution of the rotational frequency and the LUMO conductance, indicating its strong involvement. We speculate that the rotational motion is, like in other molecules [2,3], a consequence of vibrational modes excited by the relaxation of electrons tunneling into the LUMO. Besides the acquisition of information correlated to the manipulation of *TM*Pc on van der Waals surfaces this technique provides an additional approach for energetically and spatially mapping the LUMO of rotationally unstable systems.

[1] A. Nickel *et al.*, ACS Nano **7**, 191 (2013).

[2] A. J. Mayne *et al.*, Chem. Rev. **106**, 4355 (2006).

[3] B. C. Stipe *et al.*, Phys. Rev. Lett. **81**, 1263 (1998).

MA 32.5 Wed 16:45 H4

DFT Simulation of AFM-images of Fe, Cu and Si adatoms on Cu(111): different tip models — •Svitlana Polesya[1], Sergiy Mankovskyy[1], Hubert Ebert[1], and Franz Giessibl[2] — [1]Universität München, Department Chemie, Butenandtstr. 5-13, D-81377 München, Germany — [2]Institut für Experimentelle Phzsik, Univ. Regensburg, Germany

Atomic Force Microscopy (AFM) images for Fe, Cu and Si adatoms in there equilibrium positions on Cu(111) surface have been simulated on the basis of Density Functional Theory (DFT). We focus in the present work on the effect of different types of tips on the AFM image. For that reason, the forces experienced by the tip have been calculated for three tip models: single H atom, CO molecule and Cu_4 cluster. The calculated forces for the CO molecule tip fully reproduce the experimentally observed distance dependence of the force profile for a Cu adatom. Also the three fold symmetry of the lateral AFM-image for a Fe adatom, in contrast to a Cu adatom, can be explained using the results of the calculations. The nature of the repulsive forces at large lateral distances from the adatom position ($\sim$ 200-250 pm) is discussed on the basis of the electron density redistribution in the tip-adatom region.