Probing spin-dependent charge transport at single-nanometer length scales

Patrick Härtl,[1] Markus Leisegang,[1] Jens Kügel,[1] and Matthias Bode[1]

[1] *Physikalisches Institut, Julius-Maximilians Universität Würzburg, 97074 Würzburg*

Scanning tunneling microscopy (STM) has become a standard tool in surface science. It not only allows for the imaging of surfaces down to the atomic scale, the analysis of standing waves of hot charge carriers also opened the door to elucidate local electronic properties with unprecedented resolution. This technique, which is known quasiparticle interference (QPI) mapping, detects maxima and minima of the differential conductance d*I*/d*U* generated by the coherent scattering of electronic states at defects, such as step edges, surface impurities, or adatoms.

It is a severe limitation, however, that the same STM tip is simultaneously used to inject and to detect the charge carriers, i.e., after injection, the quasiparticle needs to be "routed back" for de- tection. Therefore, it is virtually impossible to spatially map the charge density which results from scattering, refraction, and diffraction around a given quasiparticle injection point. To circumvent this limitation, multi-probe STMs have been utilized to measure transport. However, due to the finite diameter of STM tips, this technique is limited to probing distances ≥ 30 nm.

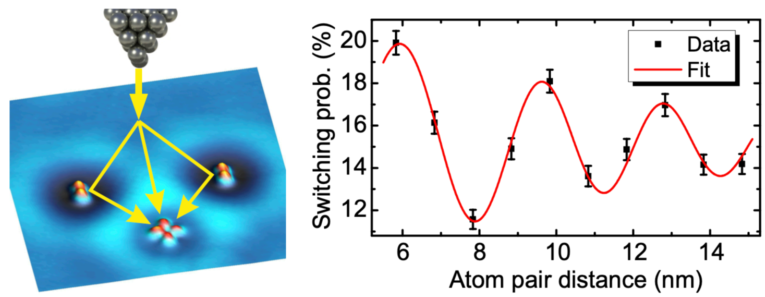

Fig. 1: (left) Principle of MONA measurements. Charge carriers are injected from a STM tip, scattered by defects, and detected by a single molecule. (right) Switching probability of the molecule observed due to the quantum interference.

The so-called molecular nanoprobe (MONA) technique represents an alternative approach. Here, charge carriers are locally in- jected by a STM tip, propagate across the surface, and are de- tected by a single molecule via a reversible electron-induced switching process, such as a tautomerization [1]. Charge transport in surface states [2, 3], anisotropic transport [4], and the damping and coherent superposition of quantum-mechanical waves has been experimentally demonstrated [5] (see Fig. 1).

In this presentation, we will report on the development of spin-polarized MONA using magnetic STM tips. For the spin–momentum-locked surface state of the Rashba alloy BiAg2 we proof that the current direction inverses as the tip magnetization is reversed by an external field. In a proof- of-principle experiment we apply SP-MONA to investigate how a single Gd cluster influences the spin-dependent charge transport of the Rashba surface alloy.

References:

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