ENGINEERING SPIN STRUCTURES ON THE ATOMIC SCALE

D. Serrate[1,2], *Y. Yoshida*[2], *P. Ferriani*[2], *A. Kubetzka*[2], *S.-W. Hla*[3], *M. Menzel*[2], *K. von Bergmann*[2], *S. Heinze*[2,4] *and R. Wiesendanger*[2]
[1]*Institute of Materials Science of Aragon, CSIC-Univ. Zaragoza, Pedro Cerbuna 12, 50009 Spain*
[2]*Institute of Applied Physics, Hamburg Universität, Jungiusstrasse 11, 20359 Germany*
[3]*Department of Physics & Astronomy, Ohio University, Athens, Ohio, USA*
[4]*Institute of Theoretical Physics and Astrophysics, Christian-Albrechts-Universität zu Kiel, Leibnizstraße 15, 24098 Kiel, Germany*
serrate@unizar.es

In practice, the smallest entity which can portray a well defined magnetic moment over time is a single magnetic atom, which can be viewed as the building block of functional magnetic nanostructures. Apart from the profound implications in magnetic data storage, the structural design and the control of the magnetic properties down to the atomic level is a prerequisite to address the new Physics emerging on the nanoscale. Spin-polarized scanning tunneling microscopy (SP-STM) has proven a powerful tool to perform real space magnetic imaging with atomic resolution [1,2]. On the other hand, STM facilities have the unique ability to precisely manipulate adatoms and molecules on surfaces [3,4]. The combination of both techniques would be the paradigm for experiments on artificially built spin structures. In this work we perform for the first time simultaneous atomic manipulation and SP-STM to achieve absolute control of the magnetization direction of transition metal atoms on a well established reference magnetic template. We used an iron coated tungsten tip to precisely move individual magnetic atoms on a magnetic substrate. Direct exchange interaction couples ferromagnetically the atom magnetization to the substrate nearest neighbors. Thus, positioning the atoms on template sites having different local spin direction allows setting the adatom magnetization by means of lateral manipulation. SP-STM performed with the same tip on several atomically engineered magnetic nanostructures reveals clear spin contrast, which can be understood on the basis of density functional theory within the generalized gradient approximation. The magnetic contrast is explained in terms of spin-resolved imaging of atomic orbitals, and it can be used to univocally determine an arbitrary atom magnetization direction. This work opens up an appealing research opportunity on the field of magnetic interactions in atomically tailored nanostructures.

References:

[1] F. Meier, L. Zhou, J.Wiebe, and R. Wiesendanger, Science, **320**, (2008) 32
[2] A. Kubetzka, P. Ferriani, M. Bode, S. Heinze, G. Bihlmayer, K. von Bergmann, O. Pietzsch, S. Blügel, and R. Wiesendanger, Phys. Rev. Lett., **94** (2005) 087204
[3] D.M. Eigler and E.K. Schweizer, Nature, **344** (1990) 524.
[4] S.-W. Hla, L. Bartels, G. Meyer, and K.H. Rieder, Phys. Rev. Lett., **85** (2000) 2777