Spin force detection of a single rare earth atom on surface

J. Chae,[1,#] D. Borodin,[1] M. Ercelik,[1,2] A.P. Sole[1] and A. Heinrich[1,2]

[1]*Center for Quantum Nanoscience, IBS, Seoul, 03760, South Korea*
[2]*Department of Physics, Ewha Womans University, 03760, South Korea*

Presenting author's e-mail: chae.jungseok@qns.science

Spin on surface is a promising platform to investigate the fundamental physics related quantum information processes. Spins on thin insulating films can be studied with scanning tunneling microscopy (STM), which requires a tunnel current to flow between tip and sample. However, the key spin properties of energy relaxation time (T1) and quantum coherence time (T2) are strongly reduced through the presence of the metal electrons. [1,2]

The atomic force microscope (AFM) is a cousin of the STM, which measures the force between a tip and the sample. We used a low-temperature AFM with a q-plus force sensor combined with STM and successfully demonstrated spin force detection of a single rare earth atom on a 2ML MgO in spin sensing regime. (see figure below) When the tip is in proximity with Ho, spin crossing happen to align tip spins ferromagnetically to the Ho spin in spin pairing regime. Interestingly, radial magnetic exchange force analysis showed the 5d orbital mediating the spin force, which was coupled to the inner 4f electrons. Moreover, we observed that the magnetic interaction between tip and the atom could be modified from antiferromagnetic to ferromagnetic by replacing the apex atom from Fe to Ag.

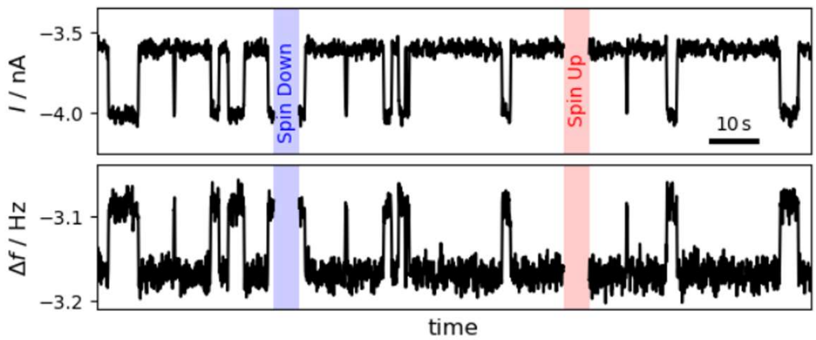

Figure 1. Random telegraph noises in simultaneously measured STM and AFM on a single Ho atom on 2ML MgO surface.

Reference

[1] W. Paul, et al. Nat. Phys. **13**, 403 (20107).

[2] P. Willke, et at. Sci. Adv. **4**, 1543 (2018).