Control of magnetic systems using STM

Deung-Jang Choi

Max Planck Institute for the Structure and Dynamics of Matter,Hamburg,Germany
E-mail: deung-jang.choi@mpsd.mpg.de

A sub-Kelvin scanning tunneling microscope (STM) allows us to build atomic model structures to engineer Spin Hamiltonians. For the first part of my talk, I will present how to manipulate atoms of different transition metal elements and construct atomic chains with different composition and size using STM. We build the chains in such that form a highly correlated spin doublet ground state exhibiting a Kondo resonance. We studied temperature and magnetic field dependence to confirm the Kondo effect in this composite magnetic system. It is revealed that the occurrence of the Kondo resonance sensitively depends on the length of the atomic chain and the spin anisotropy energy of each atom. DFT calculations and transport simulations in 2nd order Born approximation are carried out to describe the system. We build chains with different elemental composition and obtain various spin ground states. In this way, we can tailor the doublet ground state on and off. Such composite magnetic chains present a fruitful experimental model spin system to explore many-body effects and make it possible to engineer real-world implementations of complex Spin Hamiltonian.

By combining radio-frequency circuitry with sub-Kelvin STM, fast electric pump-probe pulses of nanosecond duration can be introduced into the tunneling junction with high fidelity. Second part of my talk is how to apply this technique to study dynamics of Fe trimers which can be assembled with the tip of the STM by placing Fe atoms in a regular pattern on copper nitride surface on Cu(100). The spin relaxation time of Fe trimers is found to be extremely sensitive to variations in their environment. This sensitivity can be used to sense the presence of another spin. By attaching a transition metal atom to the STM tip and approaching it to the nanostructure on the surface we deduce the coupling strength between the magnetic atoms. Furthermore, the magnetic state of long-lived spin chains can be sensed even at several nanometers distance by minute changes of the Fe trimer's spin relaxation time. This work paves the way to study and control spin dynamics of nanostructures with precisely tunable spin environments.