Current-driven single-molecule magnetism

A current of electrons can sense and control the magnetic state of nanostructured materials [1]. Obtaining similar electrical access to quantum spin systems, such as single-molecule magnets, is still in its infancy. Recent progress has been achieved by probing the spin system near thermal equilibrium. However, it is the non-equilibrium properties of the excited states that govern the time evolution of such structures and will ultimately establish the feasibility of applications in data storage and quantum information processing.

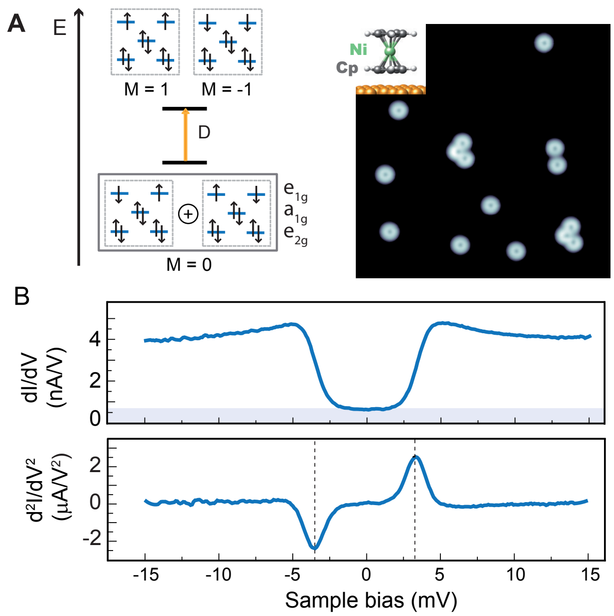

Figure 1: A) Nickelocene molecules adsorbed on a Cu(100) surface. By injecting a tunnel current from the tip of a STM we stabilize an out-of-equilibrium state: the molecule is no longer in its ground state (M=0) where the magnetization is in plane, but instead in an excited state where the magnetization is along the molecular axis (M= +1 or M=-1). **B)** The transition is monitored by IETS. It can be seen here that the transition occurs below 5 mV.

We have recently shown that nickelocene molecules offer an ideal playground for testing the interplay between a current and a single-molecule magnetization (Fig 1). By using scanning tunneling microscopy (STM) we were able to pump the electron spins of nickelocene on surfaces into excited states and change the resulting spatial orientation of the magnetization. This electrical control culminates in a 90° rotation of the molecule magnetization.

The training period will focus on how a ferromagnetic surface affects this rotation. Recent work in fact has shown that ferromagnetism can provide additional control over the magnetization of an atom [2]. Here, we will first place nickelocene onto a ferromagnetic surface to carefully characterize its structure through topographical images and its electronic properties through inelastic electron tunneling spectroscopy (IETS). We will then use the STM to manipulate vertically the molecule in order to modulate the coupling of the molecule to the ferromagnetic surface. Through this vertical manipulation we hope to gain a full electrical control onto the molecular magnetization of nickelocene.

More info on the STM group here: www-ipcms.u-strasbg.fr/stmipcms/

[1] C. Chappert, A. Fert, F.N. Van Dau, Nature Mater. **6**, 813 (2007)
[2] S. Loth *et al.*, Nature Phys. **6**, 340 (2010)

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