Using Electronic Coupling to Control Magnetic Properties at the Atomic Scale

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The magnetic properties of individual atomic or molecular quantum spins can be strongly modified and tuned by the local environment. This includes not only the influence of the local structure but also the local electronic coupling. Using scanning tunneling microscopy and spectroscopy, we study the effects of interactions on individual magnetic atoms and molecules that are separated from an underlying metallic surface by a thin-insulating layer of copper nitride (Cu_2N) [1]. For Co atoms on large Cu_2N islands, we find that exchange coupling of the spin to the metallic bath can result in Kondo screening as well as dramatically shifting the energy levels of the spin and modifying its effective magnetic anisotropy, the property that determines the stability of its spin orientation. By controlling the exchange coupling, we can tune both the strength of the Kondo screening of the spin as well as the anisotropy energy over a broad range of values. Furthermore, this system constitutes one of the few cases in which an open quantum system's energy levels, rather than just its excited-state lifetimes, can be controllably and observably renormalized. We also study the electronic transport through individual metal-doped phthalocyanine molecules on Cu_2N. For tunnel junctions containing individual FePc molecules, we find regions of negative differential resistance that shift with magnetic field at a rate that is two orders of magnitude larger than the Zeeman energy [2]. The negative differential resistance is caused by transient charging of the molecule and occurs at voltages corresponding to the alignment of sharp resonances in the filled and empty molecular states with the Cu(001) Fermi energy. An asymmetric voltage-divider effect enhances the apparent voltage shift of the negative differential resistance with magnetic field, which inherently is on the scale of the Zeeman energy. These results suggest new ways in which electronic coupling can be used for controlling the properties of nanoscale spintronic devices.

[1] J.C. Oberg *et al.*, *Nature Nanotechnology* **9**, 64 (2014)
[2] B. Warner *et al.*, accepted by *Nature Nanotechnology* (2014)