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Single-Atom Spin-Flip Spectroscopy[1]

ANDREAS HEINRICH, IBM Almaden Research Center

The energy levels of a magnetic atom split in an applied magnetic field. We recently built an STM with a base temperature of 0.6K and a maximum magnetic field of 7T. These operating conditions allow the direct measurement of the Zeeman energy with inelastic tunneling spectroscopy [1]. We found that the Mn atoms have to be removed from the metal conduction electrons to suppress strong interactions such as the Kondo effect; we use Al_2O_3 grown on NiAl (110). The tell-tale sign of a vibrational mode in inelastic spectroscopy is the predictable frequency shift with mass. In spin-flip spectroscopy we can continuously tune the Zeeman energy with the applied magnetic field. We observe that the measured Zeeman energy is proportional to the magnetic field which yields a local measure of the 'g-value'. We find g- values in the vicinity of g=2, however the exact value depends on the local environment. When a Mn atom sits near the edge of the oxide film we observe strong coupling with the conduction electrons of the substrate resulting in a Kondo effect with Kondo temperatures of a few Kelvin. In contrast to previous STM work we do not observe the Kondo resonance as a Fano line shape. The logarithmic temperature dependence of the Kondo resonance as well as its splitting in magnetic field corroborates the interpretation as a Kondo effect. [1] A.J. Heinrich, J.A. Gupta, C.P. Lutz, D.M. Eigler, Science 306, 466 (2004).

[1]IBM Almaden Research Center