Dynamics of individual paramagnetic spins detected with magnetic exchange force

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Dynamics of single atomic spins allow for the exploration of quantum mechanical effects and the impact of fundamental interactions on the atomic-scale. In that, spin-polarized scanning tunneling microscopy (STM) is capable of detecting the switching of individual spins [1,2]. Atomic force microscopy (AFM), on the other hand, gives access to atomic-scale magnetic forces. These forces have been investigated on stable spins or magnetically ordered lattices [34]. Here, we show magnetic exchange force detection on a single paramagnetic Fe atom on MgO/Ag(100).

We use an approach, where control of the spin ground state allows us to extract the magnetic forces on a single atom. Additionally, we investigate the dynamics of this spin and their effect on the magnetic forces between the spin and the cantilever (Fig. 1) by simultaneously measuring frequency shift, dissipation and time-dependent state of the spin, encoded in the tunnel current. We find that the switching spin interacts strongly with the AFM cantilever and undergoes a ground state reversal as a function of exchange interaction with the tip. This interplay between magnetic exchange interactions and spin dynamics can reveal novel dynamics in driven quantum systems.

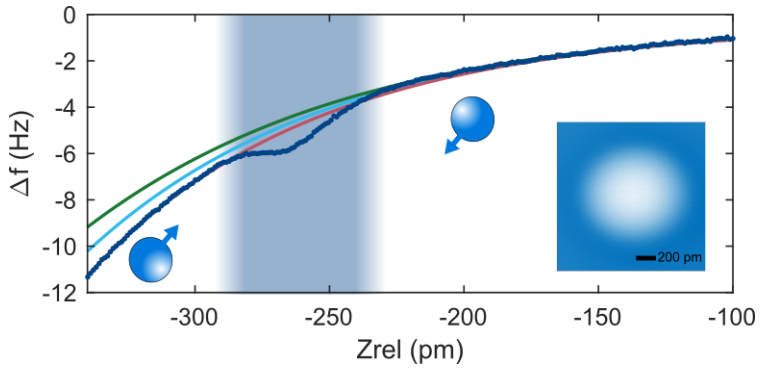

Figure 1. Magnetic exchange force on a single Fe atom on MgO/Ag(100). The exchange force counteracts the external magnetic field B_{ext}= 1.5 T and causes a ground state reversal at Z_{rel}= -255 pm. In the reversal region (blue), dynamics of the spin cause a dip in the frequency shift, Δf, of the AFM cantilever. (Voltage V = -1 mV, AFM oscillation amplitude A_{osc} = 8 pm, Z_{rel} = 0 pm at tunnel junction setpoint of 70 pA at 50 mV)

Reference

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