Probing the zero field evolution of single atom magnets

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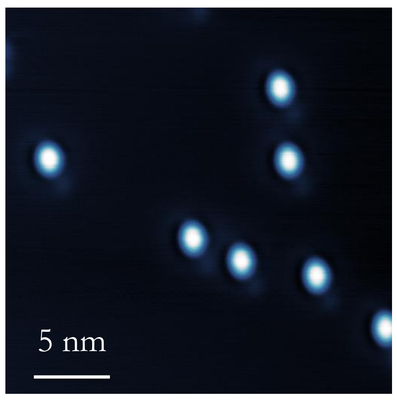
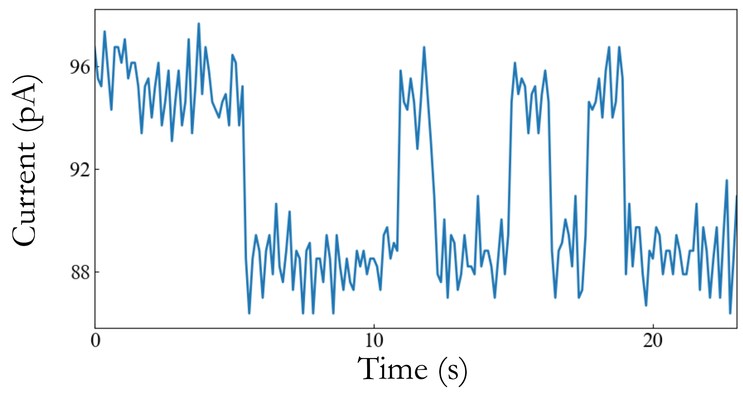
Motivation

Ho is read/writeable single atom magnet



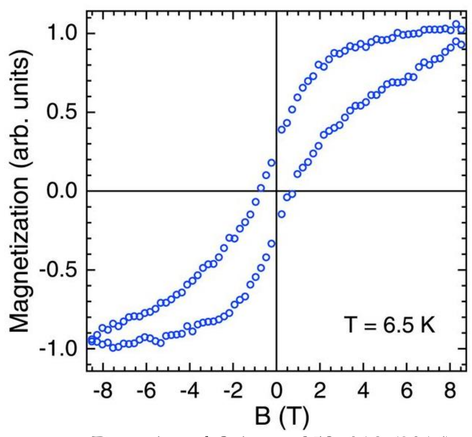
STM topography



Ho two state switching

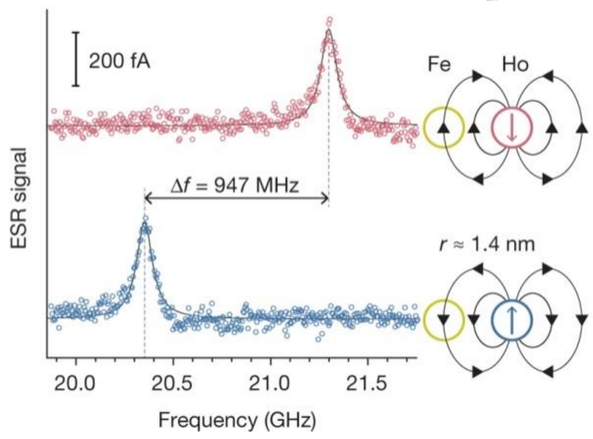
Debate over magnetic moment

X-Ray Absorption (7,5 μ_B)



Donati *et al.* Science **352**, 318 (2016).

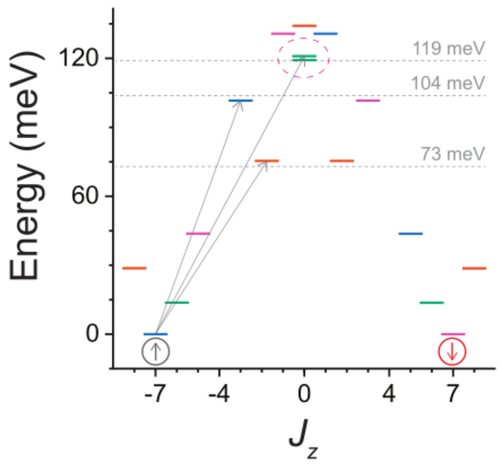
ESR-STM (10.1 μ_B)



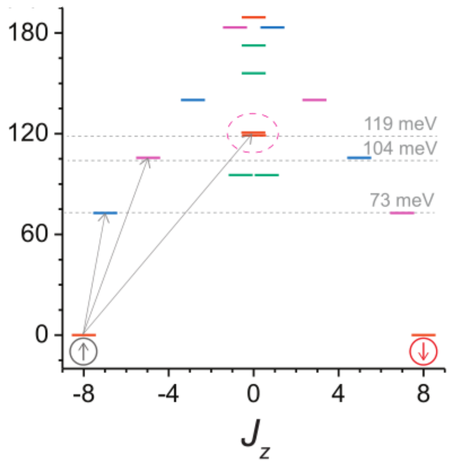
Natterer *et al.*, Nature **543**, 226 (2017).

Implies different ground states

$J_z = 7$, $B_z = 10$ mT



$J_z = 8$, $B_z = 10$ mT

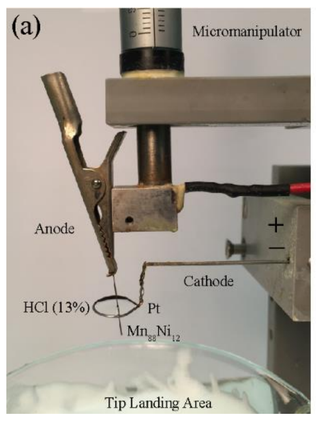


Natterer *et al.*, Phys Rev. Lett **121**, 027201 (2018).

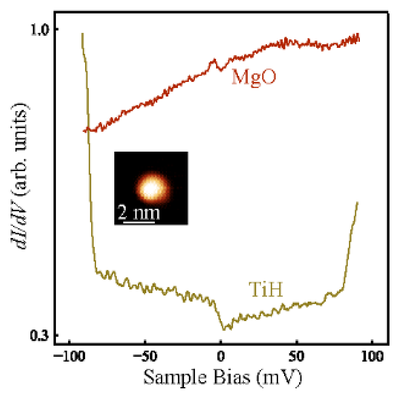
- Is Ho stable at zero field?
- What is its ground state?

Antiferromagnetic SP-STM

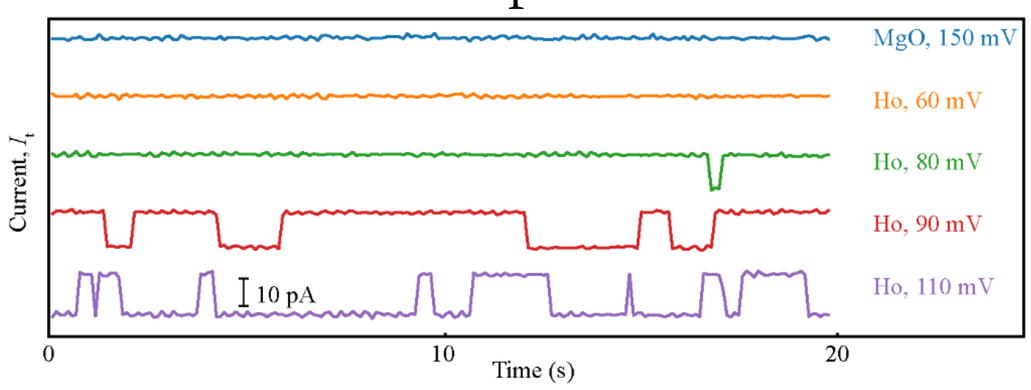
Conventional fabrication



In-plane SP



Out-of-plane SP

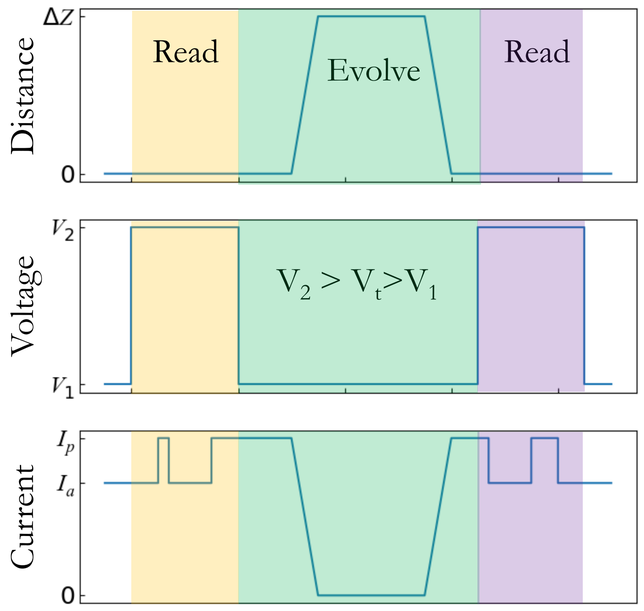


Forrester *et al.* under review at Rev. Sci. Instr.; preprint at arXiv:1807.00364

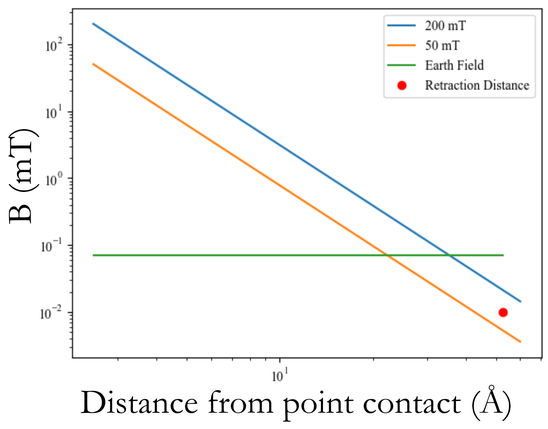
- Stray field decays rapidly
- SP-STM without external field

Zero Field Stability

Experimental setup



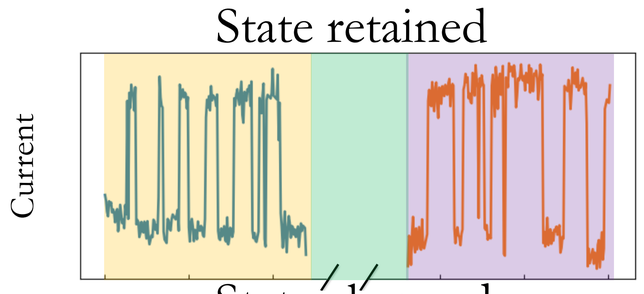
Stray field



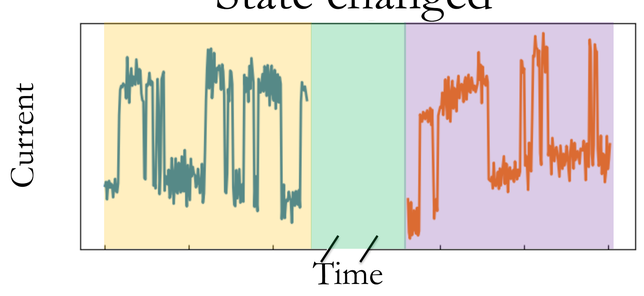
- 5 nm retraction
- 60 s at retraction distance

Results

State retained



State changed



We see

- 3.0 % ± .3 % Up to Down
- 0.0 + .1 % Down to Up

We expect

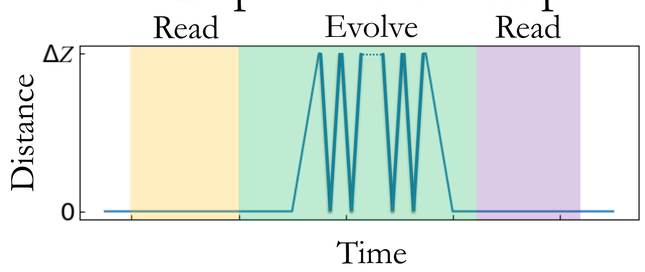
- 0.96 % Up to Down
- 1.1 % Down to Up

Does this make sense?

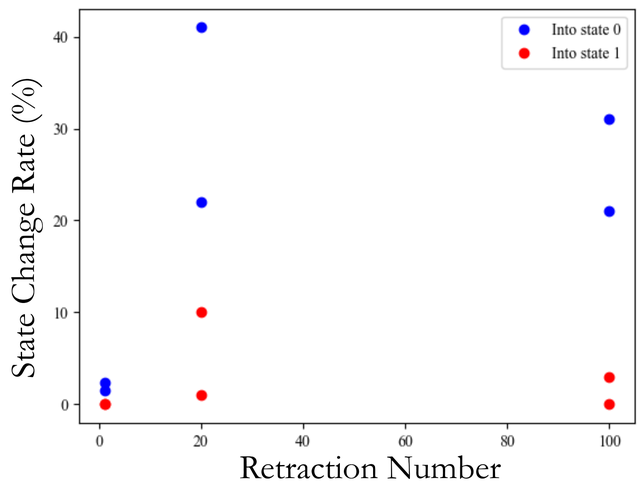
Unaccounted for flips

Increase number of retractions

Experimental setup



Results



- Flip rate increases when retractions are increased
- Excess flip events are not from time spent at zero field
- Excess flips from process of sweeping tip
- Crossing zero field at intermediate distance?
- Avoided level crossings?

Conclusions

- Holmium is a stable magnet at zero field
- This will inform theory for determining ground state
- Exists spin flip mechanism at intermediate field values

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