Exploring Quantum Size Effect of Antiferromagnetic 120° Néel State on Mn Nanoislands by Spin-Polarized Scanning Tunneling Microscopy

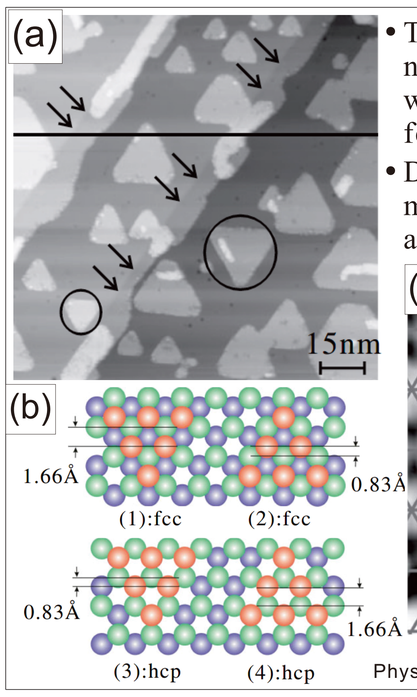
Yu-Tung Lin[1]*, Chieh-Lin Li[1], Chia-Ju Chen[1], Yi-Pin Chen[1], Tzu-Yen Cheng[1], Pin-Jui Hsu[1]

[1]Department of Physics, National Tsing Hua University, Hsinchu City, Taiwan

*E-mail: jeremylin0911@gmail.com

Introduction

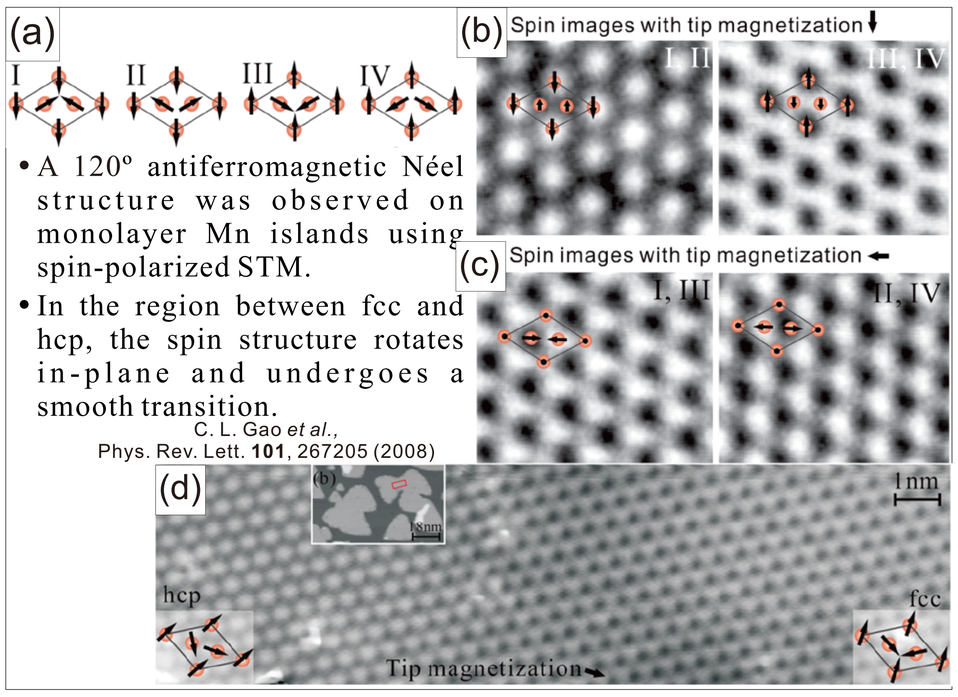
Mn/Ag(111)



- Triangular Manganese nanoislands on Ag(111) with two stacking types: fcc and hcp.
- Deposit Mn at 200K, the majority of Mn islands are found at fcc sites.

C. L. Gao *et al.*, Phys. Rev. Lett. **101**, 267205 (2008)

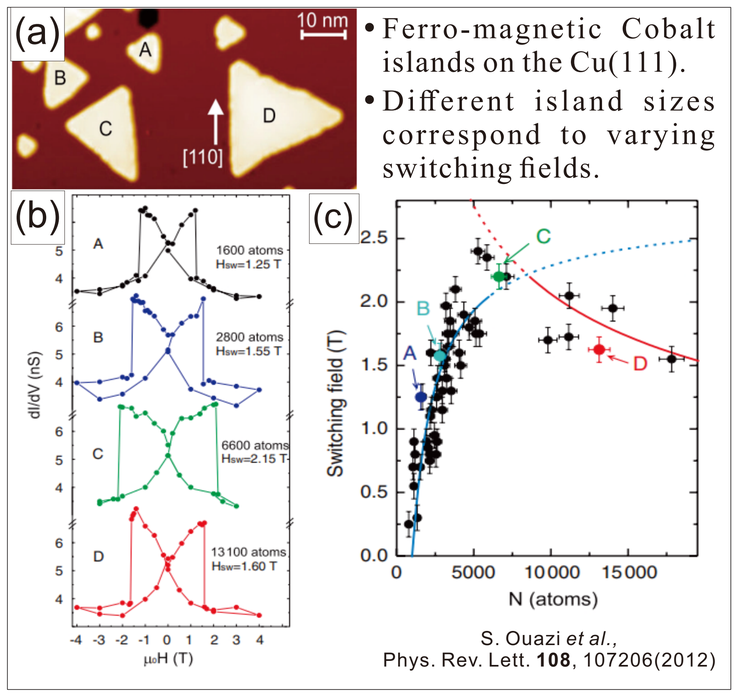
120° Néel Structure



- A 120° antiferromagnetic Néel structure was observed on monolayer Mn islands using spin-polarized STM.
- In the region between fcc and hcp, the spin structure rotates in-plane and undergoes a smooth transition.

C. L. Gao *et al.*, Phys. Rev. Lett. **101**, 267205 (2008)

Quantum Size Effect

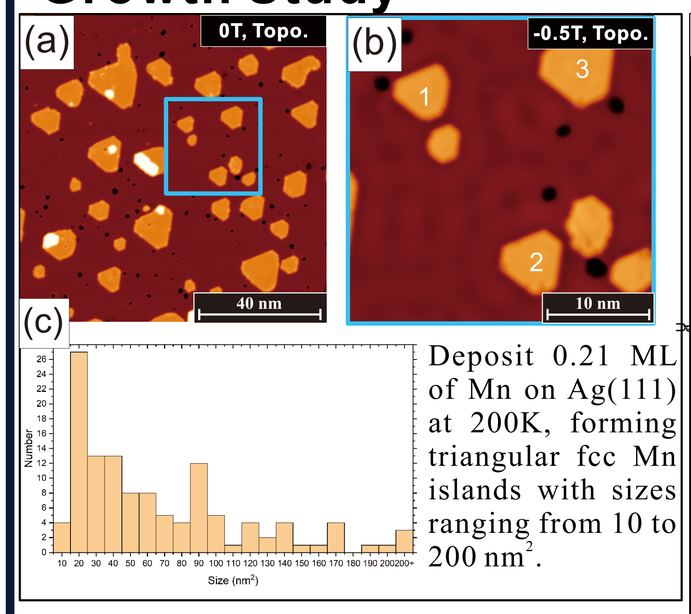


- Ferro-magnetic Cobalt islands on the Cu(111).
- Different island sizes correspond to varying switching fields.

S. Ouazi *et al.*, Phys. Rev. Lett. **108**, 107206(2012)

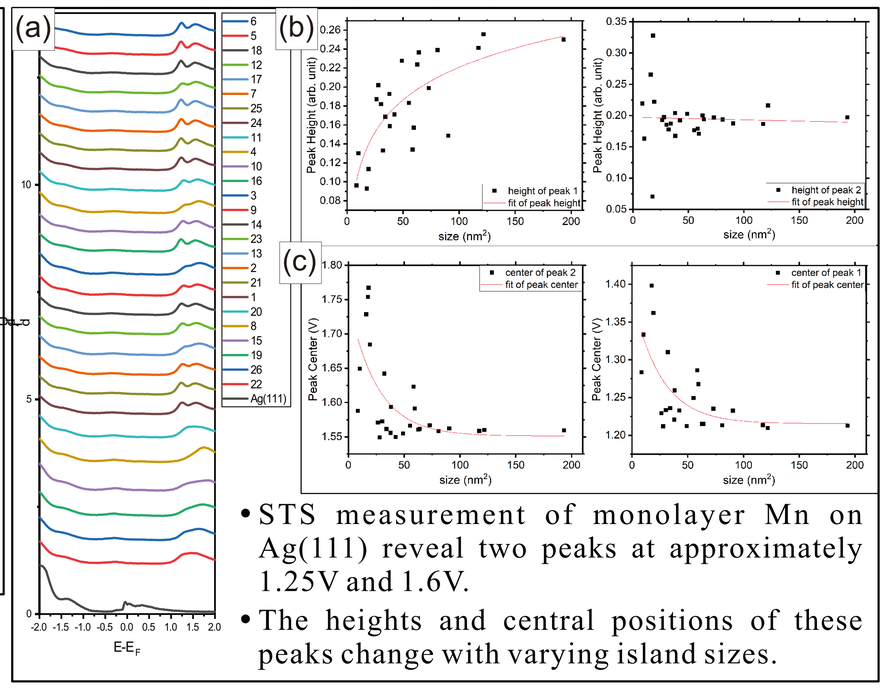
Experiment Results

Growth Study



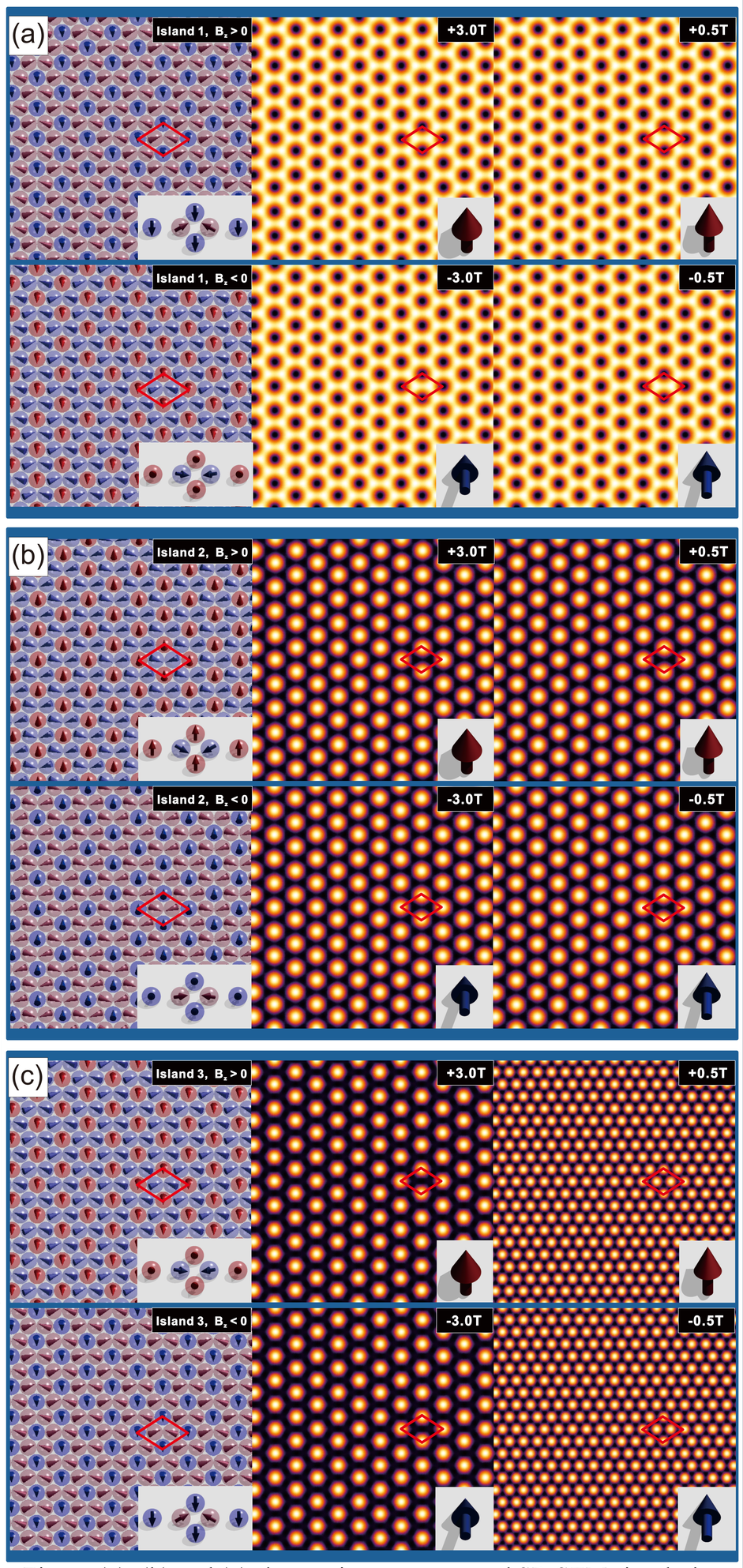
Deposit 0.21 ML of Mn on Ag(111) at 200K, forming triangular fcc Mn islands with sizes ranging from 10 to 200 nm^2.

STS Measurement



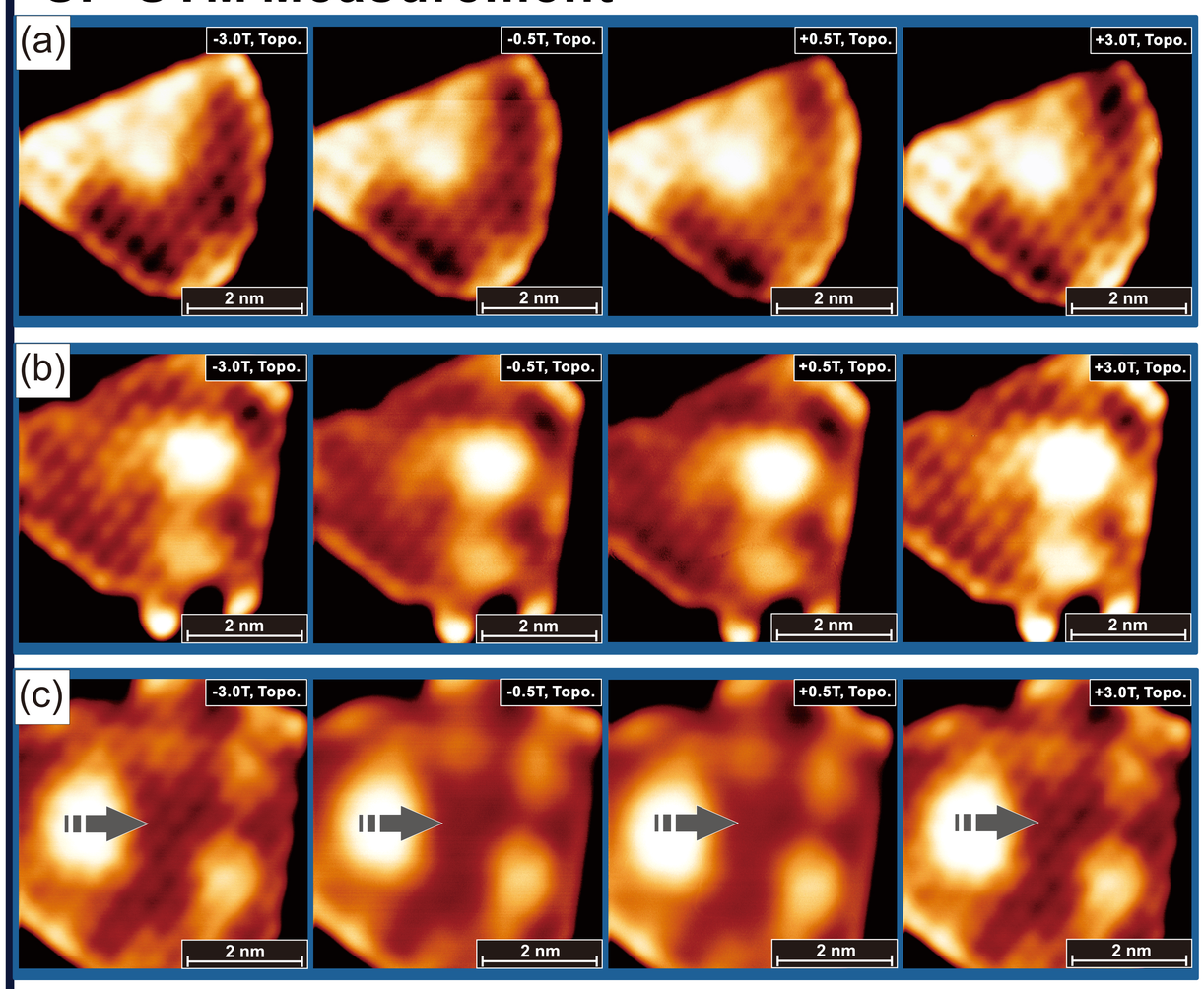
- STS measurement of monolayer Mn on Ag(111) reveal two peaks at approximately 1.25V and 1.6V.
- The heights and central positions of these peaks change with varying island sizes.

SP-STM Simulation



- Figure (a), (b) and (c) show spin structures and SP-STM simulations of island 1, 2 and 3 respectively. Inset indicate the tip magnetization. We observe a 1-by-1 pattern on island 3 at ±0.5T, indicating the absence of magnetic signals.

SP-STM Measurement



- Figure (c) shows the pattern of island 3 vanishes at an applied magnetic field of ±0.5T, while the other two islands, shown in Figure (a) and (b), remain unchanged.
- This implies that the 120° Néel structure on these islands might possess an out-of-plane component, and prone to reversal in response to alterations in the magnetic field direction.

Island \ Tip	Flip	Not flip
Flip	Agree with the experiment results.	The inversion of magnetic field should leads to inverse contrast of pattern.
Not Flip	The inversion of magnetic field should leads to inverse contrast of pattern.	Pattern should not change.

- Only when both the tip and the spin structure reverse simultaneously does it align with our experimental results.

Summary

- In the STS, The center of the peaks at 1.25V and 1.6V shift with varying island size. additionally, only the height of the peak at 1.25V changes with island size.
- Results from SP-STM indicate the disappearance of the spin signal for island 3 under specific magnetic field, while the patterns of other islands remain unchanged.
- We suggests that the 120° Néel structure on these smaller islands possesses an out-of-plane spin component and is prone to flipping with changes in the magnetic field direction.