# TOPOLOGICAL BARRIER FOR SKYRMION LATTICE FORMATION IN MnSi

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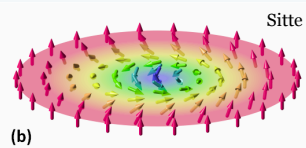
## MOTIVATION

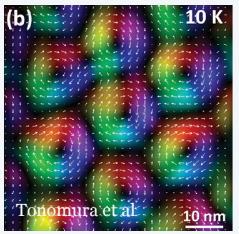
- Skyrmions are magnetic "bubbles" that are great candidates for information storage due to their topological formation energy.
- Skyrmions in bulk materials tend to arrange themselves into lattices (SkLs).
- The SkL of MnSi is known to be particularly stable, but its formation energy has yet to be measured.




**Bloch type skyrmion**

## SANS ON MnSi

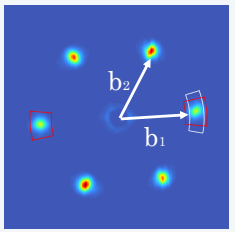
- Small angle neutron scattering (SANS) allows us to image the SkL in reciprocal space.
- This reveals the structure, order, and sample volume fraction of the SkL.




Triangular SkL

(Real Space)

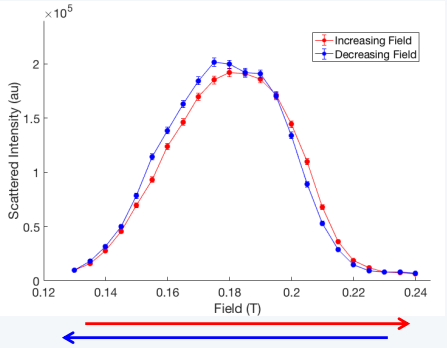
SANS



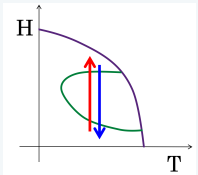

6-fold Bragg Pattern

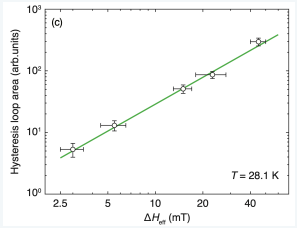
(Reciprocal Space)

## SkL HYSTERESIS

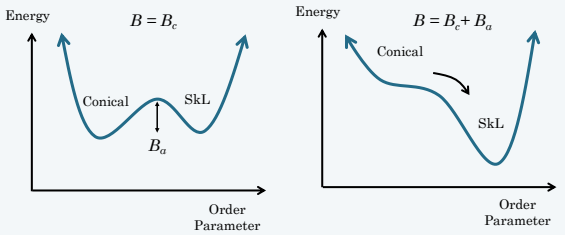



- Plotting the SANS intensity as a function of field through the SkL phase, we notice a hysteresis.
- This hysteresis demonstrates nesting for shorter field loops.
- The skyrmion formation energy must be inhibiting the phase transition!

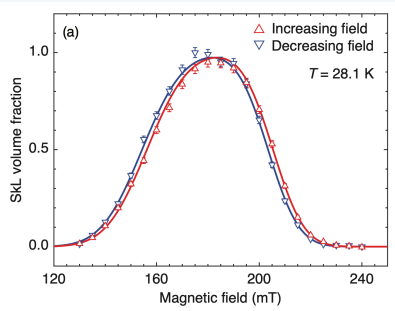



## PREISACH MODEL

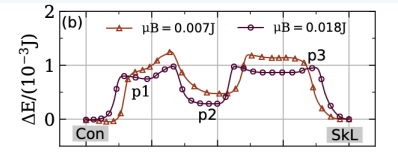


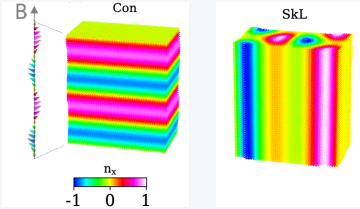

- Phase transition inhibited by activation barrier $B_a$.
- Excellent agreement with data, finding $B_a$ is ~1 mT for both phase transitions.




## SPIN SIMULATIONS

- We can use spin simulations to find min-energy paths between phases.

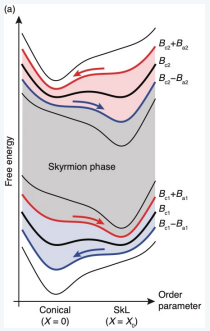



- Energy barrier depends on SkL domain size!

## CONCLUSIONS

- The topological formation energy inhibits the Con-SkL phase transition in MnSi.
- Skyrmions form in domains of ~100 skyrmions.
- Formation energy in this sample is roughly ~7 eV/ skyrmion.




## FULL PAPER

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