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Reversal mechanism of skyrmionic textures in nanostructures via Bloch point occurrence and propagation

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Introduction

- Topologically stable magnetic skyrmions have the **potential to provide new solutions** for efficient low power data processing and retrieval.

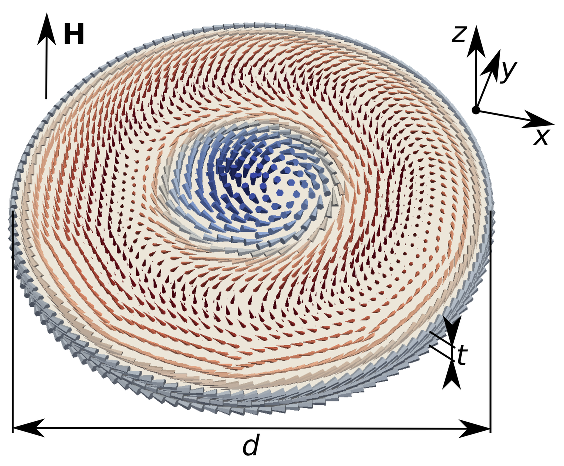
- Geometrically enhanced stability creates large hysteresis in absence of both magnetocrystalline and dipolar based shape anisotropy, suggesting the existence of **Dzyaloshinskii-Moriya (DM) based shape anisotropy** [1].

- Hysteresis study shows that the skyrmionic core orientation can be changed using an external field [1]. Here, we study the **skyrmionic core reversal mechanism**.

Model and simulation

- nanostructure:

material: **FeGe**



- Hamiltonian:

$$W = \underbrace{A(\nabla \mathbf{m})^2}_{\text{isotropic exchange}} + \underbrace{D\mathbf{m}\cdot(\nabla\times\mathbf{m})}_{\text{Dzyaloshinskii-Moriya}} \underbrace{- \mu_0 \mathbf{H}\cdot\mathbf{m}}_{\text{Zeeman}}$$

- Skyrmion number:

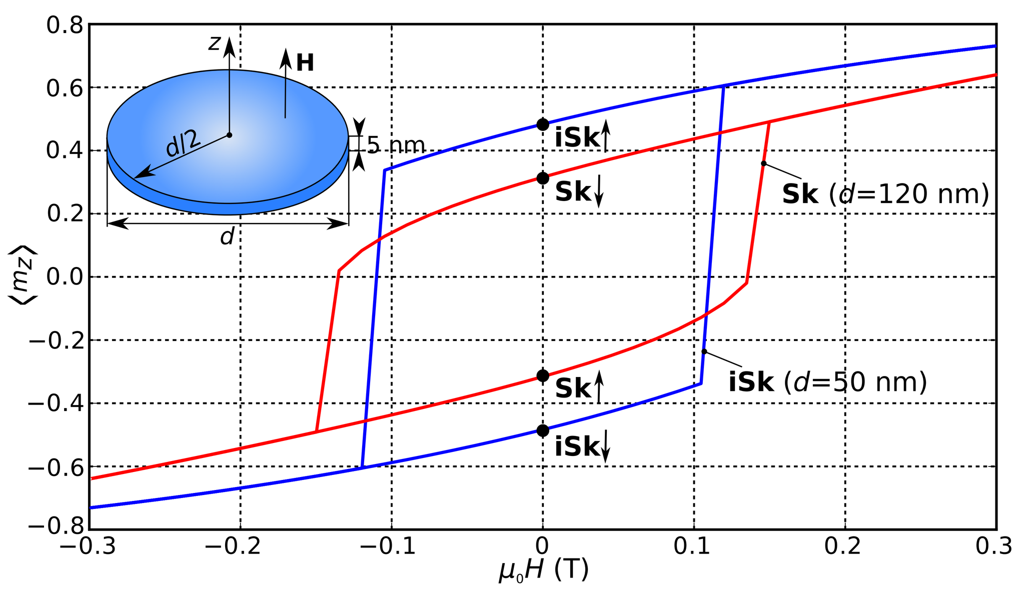
$$S = \frac{1}{4\pi}\int \mathbf{m}\cdot\left(\frac{\partial \mathbf{m}}{\partial x}\times\frac{\partial \mathbf{m}}{\partial y}\right)\mathrm{d}x\mathrm{d}y$$

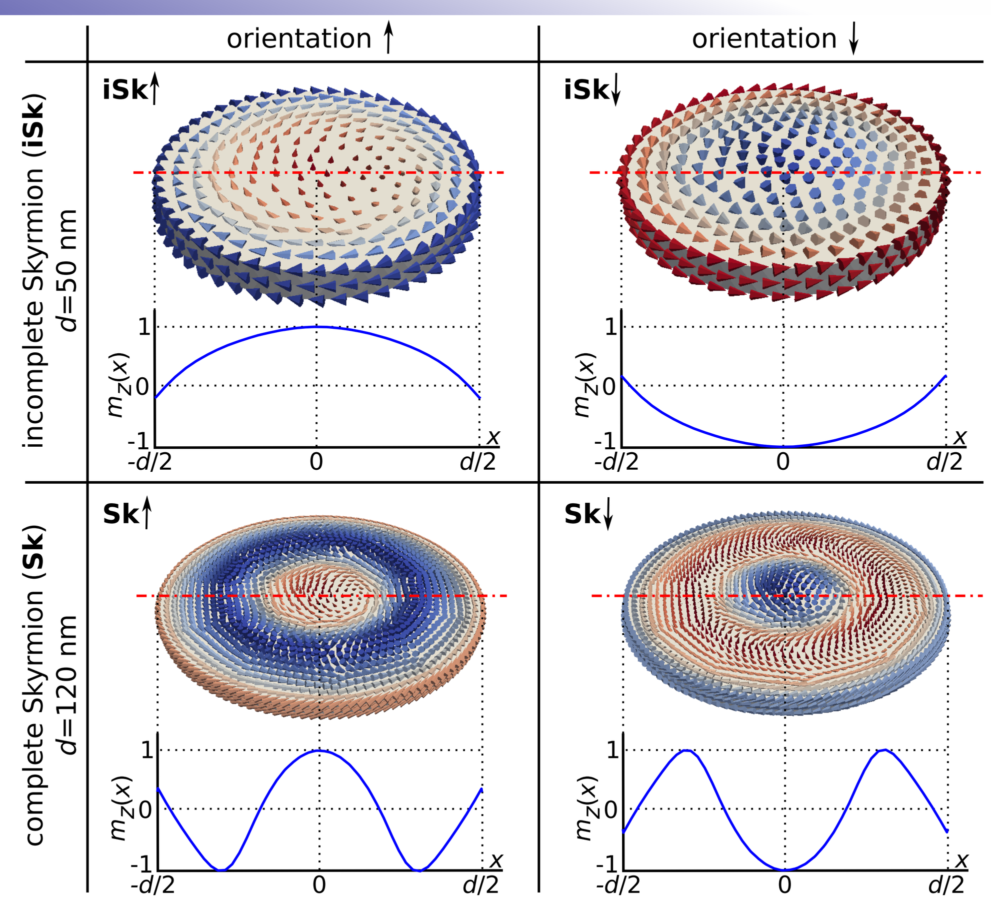
- Finite elements based simulator - **finmag**.
- Maximum mesh discretisation is **1.5 nm**.
- Magnetisation dynamics is governed by the **LLG equation**.
- Skyrmion number computed over **xy-cross section at the bottom boundary**.
- The system is relaxed for -125 mT external magnetic field and then, the **external field is reduced abruptly** to -115mT and magnetisation dynamics is recorded.

References

[1] Beg, Marijan *et al.*, **Finite size effects, stability, hysteretic behaviour, and reversal mechanism of skyrmionic textures in nanostructures** (2014), Preprint at: `arxiv.org/abs/1312.7665`

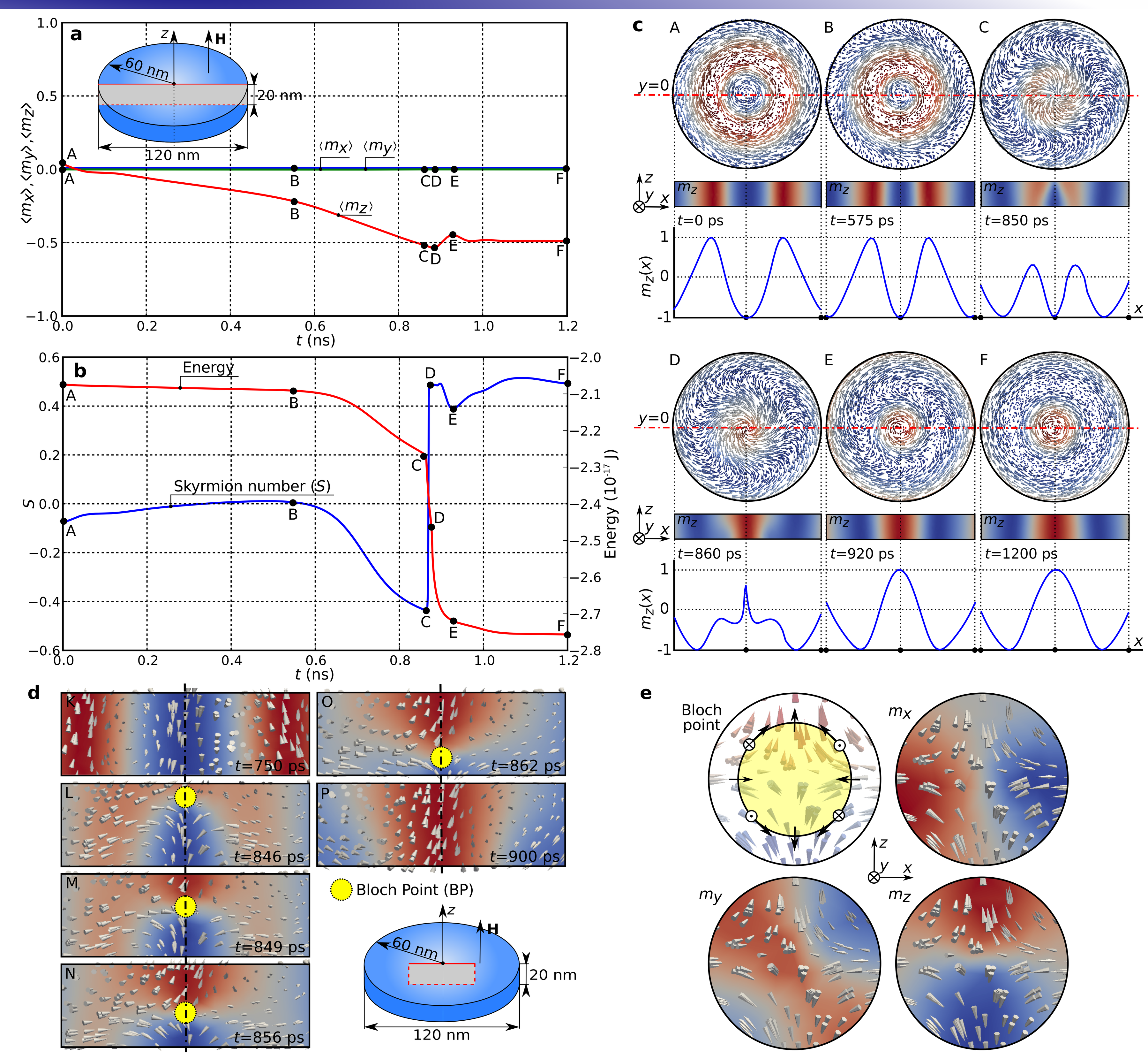
Hysteretic behaviour





- Large hysteresis in absence of both magnetocrystalline and dipolar based shape anisotropy, suggesting the existence of **Dzyaloshinskii-Moriya based shape anisotropy**.

Reversal mechanism



Conclusion

- The hysterestic behaviour of skyrmionic textures occurs as a consequence of **energy barrier** between two states with different core orientation (up and down). This suggests the existence of **Dzyaloshinskii-Moriya based shape anisotropy**.

- Reversal of skyrmionic textures in nanostructures occurs via **Bloch point occurrence and propagation**: Bloch point enters the sample at the top boundary, propagates towards lower boundary, where it leaves the sample.

Acknowledgements

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