

Skyrmionic texture stabilisation mechanisms in confined helimagnetic nanostructures

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Introduction

- Skyrmionic textures are **the ground state** in confined helimagnetic nanostructures in absence of both external magnetic field and magnetocrystalline anisotropy [1].

- Skyrmionic texture ground states emerge in the form of **incomplete Skyrmion (iSk)** and **isolated Skyrmion (Sk)** [1].

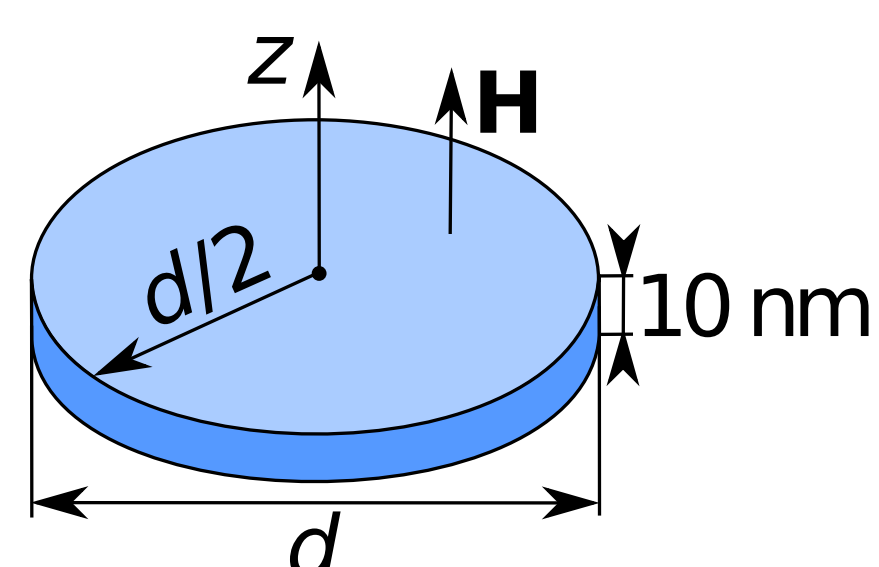
- This work examines what is the **possible stabilising mechanism** of skyrmionic textures in confined helimagnetic nanostructures.

- We study the importance of **demagnetisation energy**, as well as the **magnetisation variation in the out-of-film direction** [2].

Model and simulation

- geometry:

material: **FeGe**



- Hamiltonian:

$$E = \underbrace{A(\nabla\mathbf{m})^2}_{\text{symmetric exchange}} + \underbrace{D\mathbf{m} \cdot (\nabla \times \mathbf{m})}_{\text{Dzyaloshinskii-Moriya}} - \underbrace{\mu_0 M_S \mathbf{m} \cdot \mathbf{H}}_{\text{Zeeman}} + \underbrace{w_D}_{\text{demagnetisation}}$$

- Scalar value S_a [1]:

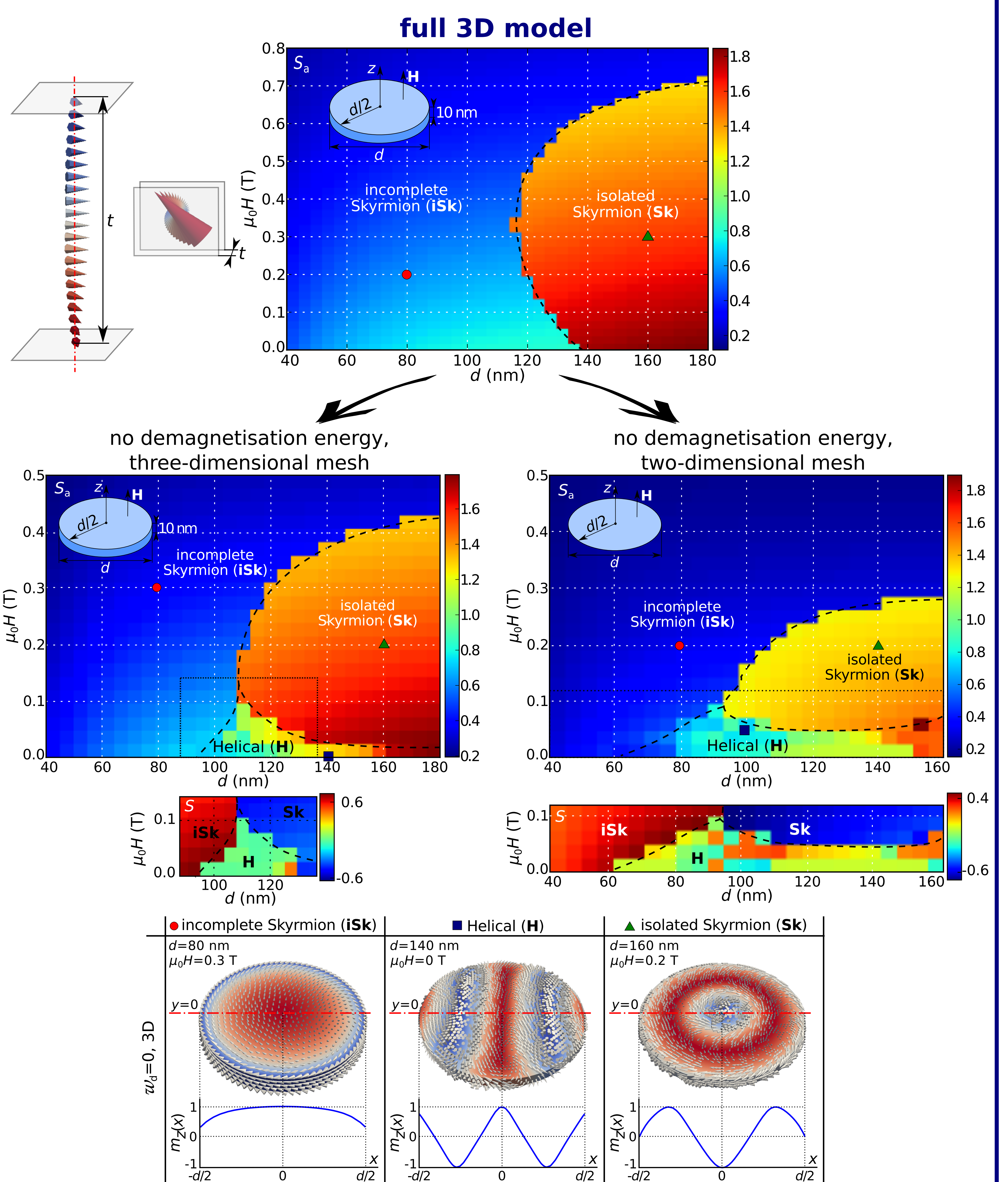
$$S_a = \frac{1}{8\pi} \int \left| \mathbf{m} \cdot \left(\frac{\partial \mathbf{m}}{\partial x} \times \frac{\partial \mathbf{m}}{\partial y} \right) \right| d^3r$$

- **Full 3D finite elements** simulation model.
- No assumption about translational invariance of magnetisation in the out-of-plane direction.
- Full computation of the demagnetisation energy.
- Maximum mesh discretisation is **3 nm**.
- Magnetisation dynamics is governed by the **LLG equation**.
- The system is relaxed from **multiple initial states** [1].

References

- [1] Beg, M. *et al.*, *Scientific Reports* **5**, 17137 (2015)
[2] Rybakov *et al.*, *Physical Review B* **87**, 094424 (2013)

Stabilising mechanism



Conclusion

- We demonstrate that **demagnetisation energy plays a crucial role** for the stability of skyrmionic textures in helimagnetic nanostructures.

- As shown by Rybakov *et al.* [2] we also demonstrate that **magnetisation variation in the out-of-film direction** allows the reduction of total energy for the skyrmionic textures.

- Our work shows that **neglecting demagnetisation energy or modelling three-dimensional samples using two-dimensional meshes is not always justified**.

Acknowledgements

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