Exploring the creation of topological magnetic structures by interfacial DMI and magnetic field in 2D ferromagnets

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Topological magnetic structures and especially magnetic skyrmions are the prime candidates for introducing topological systems to the state of the art spintronics [1]. Since the presence of the Dzyaloshinskii–Moriya exchange interaction (DMI) is the main mechanism for the stabilization of magnetic skyrmions we explored the introduction of interfacial DMI in centrosymmetric 2D ferromagnets. In this work we present two case studies where topological magnetic structures emerge in two of the most promising 2D ferromagnets, namely $CrTe_2$ [2] and Fe_3GeTe_2 [3]. In the first case we studied with ab initio and atomistic spin simulations the effect of the interfacial DMI, in the heterostructures $CrTe_2/WTe_2$ and $CrTe_2/MoTe_2$, on the stabilization of magnetic skyrmions. In addition, we engineered a field-controlled Néel-type skyrmion lattice (Figure 1. a), where the skyrmion lattice is robust against thermal fluctuations close to T_c (Figure 1. b) [4]. In the second case we studied a Fe_3GeTe_2 thick flake where the interfacial DMI emerged from the presence of the native oxide epilayer. Here by combining experimental magneto-optical Kerr effect (MOKE) imaging and micromagnetic simulations we studied the emergence of two magnetic phases close to the saturation by employing a specific magnetic field protocol. The first one consisting of Néel-type double wall domains showing the structure of a skyrmionium [5] that order to a regular lattice (Figure 2. a). Those double wall domains collapse at higher fields to solid magnetic bubbles which, based on our micromagnetic calculations, are Néel-type skyrmions (Figure 2. b). Thus, by choosing appropriate combinations of interfacial DMI and magnetic field one can produce tailor made topological magnetic structures in 2D ferromagnets heterostructures.

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References

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[2] X. Zhang et al., Nat Commun., 12 (2021) 2492
[3] G. J. Seo et al., Sc. Adv., 6 (2020) eaay8912
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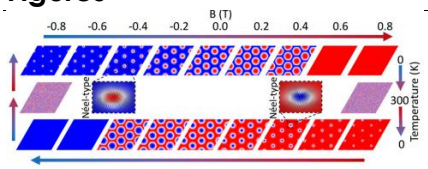
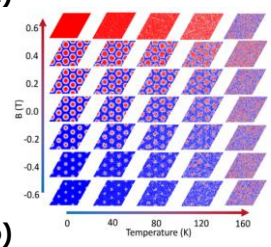
Figures

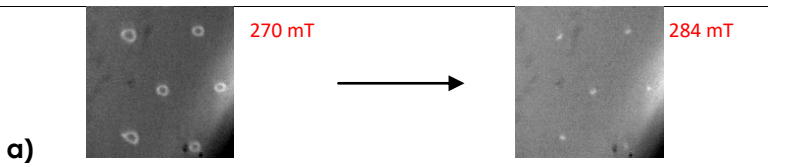


a)

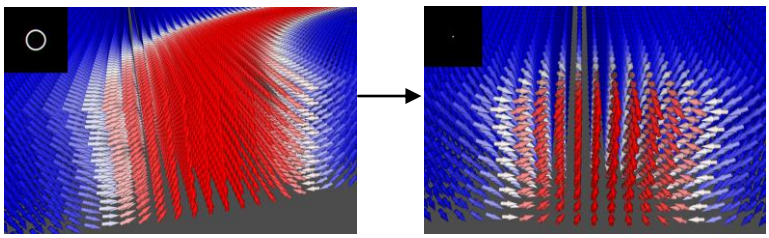


b)

Figure 1: a) A complete transition cycle of the spin texture from -0.8 to 0.8 T, b) Skyrmion phase diagram as a function of the temperature and magnetic field.



a)



b)

Figure 2: a) Polar-MOKE images of double wall domains (left) and their collapse to spot domains (right),
b) 3D representation of the simulated spin configuration of the double wall domains (left) and Néel skyrmion (right).