Non-collinear three-dimensional textures in magnetic multilayers: Hatching of skyrmionic cocoons

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Two-dimensional magnetic textures such as skyrmions or chiral domain walls were mostly under focus for the last decade, but recently interest has surged for more complex objects which display an inhomogeneous behaviour over the vertical dimension. Interesting examples include bobbers which could become remarkable assets for the development of logic devices [1], the recently observed hopfions [2], or even different skyrmions phases [3].

In this study, we engineer and explore aperiodic metallic multilayers stabilizing new magnetic textures, which we named skyrmionic cocoons [4]. At low magnetic field, they resemble tubular skyrmions but upon an increase of the out-of-plane field, they shrink and disappear from the outer layers becoming elongated ellipsoids. By carefully tuning the thickness of each magnetic layer, it is possible to observe concomitantly two distinct objects in a single sample, as shown by the strong difference in the magnetic force microscopy (MFM) contrasts in Fig. 1. X-ray holography confirms the MFM observations and provides information about the averaged magnetization through the layers, and allow the cocoon-cocoon interaction to be observed. Finally, their 3D nature was recently confirmed using laminography.

Combining all these observation techniques with magneto-transport as well, we can reliably compare our experimental observations with micromagnetic simulations, displaying these new 3D textures. The existence and field-dependent behaviour of such textures could represent interesting possibilities for potential applications.

References

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Figures

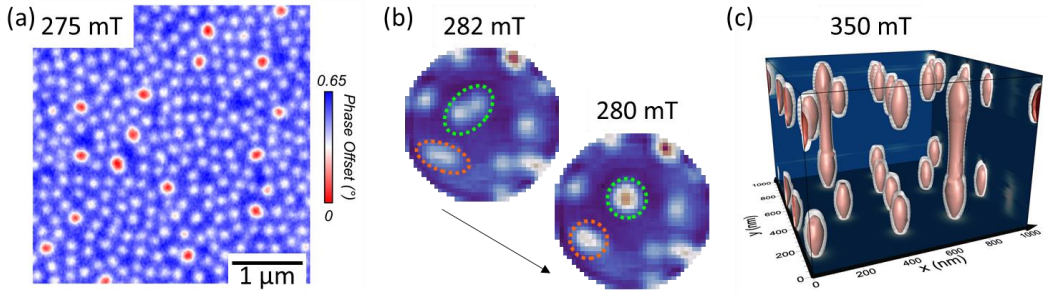

Figure 1: Cocoons and skyrmion tubes. (a) Experimental MFM phase maps displaying two types of textures. (b) Holography images showing alignment of cocoons before their fusion at lower field. Blue and red colours are associated to up and down magnetizations. (c) Corresponding micromagnetic simulations, evidencing the 3D nature of the cocoons and the skyrmion tubes (magnetization iso surfaces at m_z = -0.8 are displayed in red).