Magnetic nature of complex vortex-like structures

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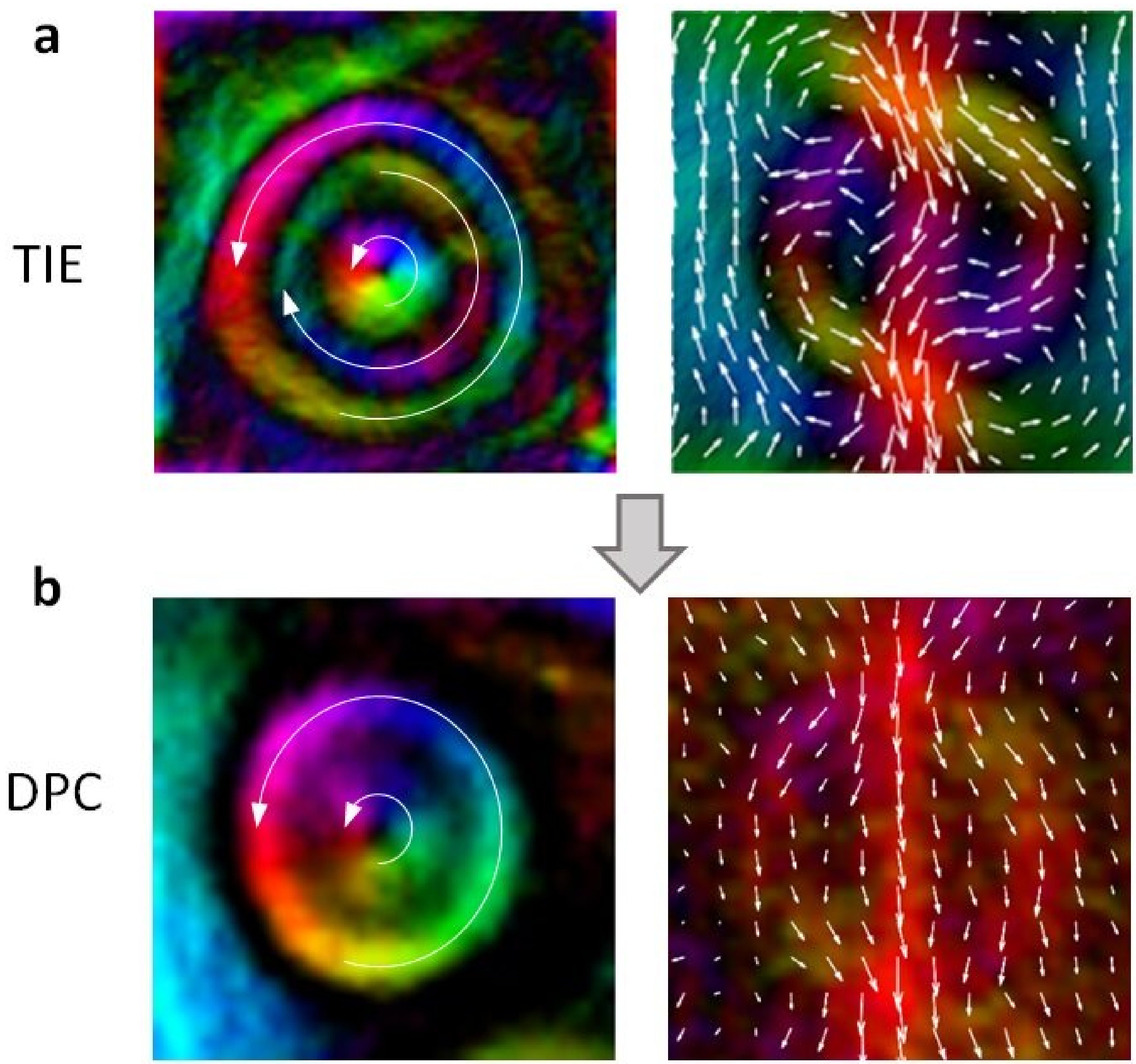
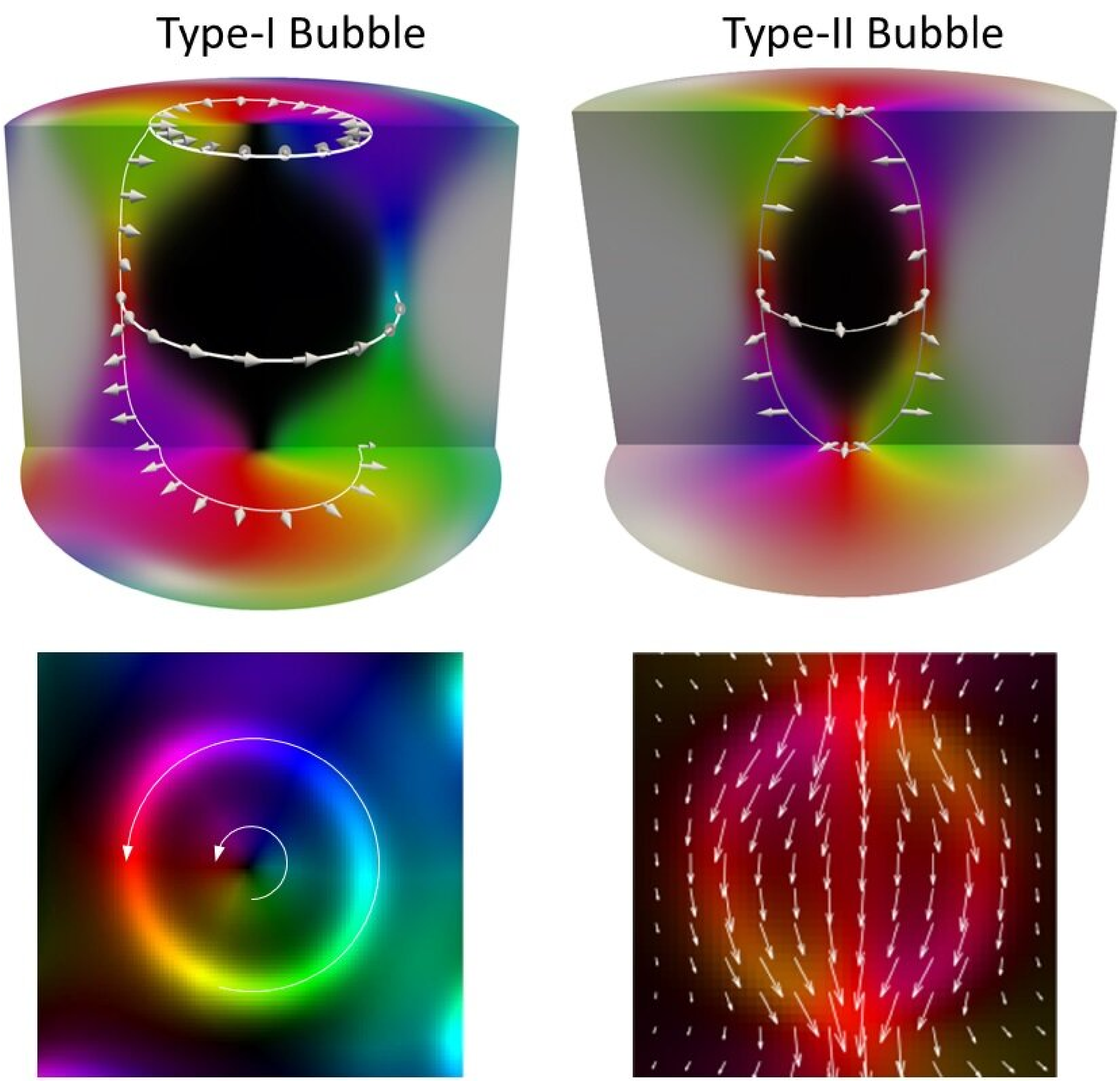


(a) Multi-ring and arc-shaped vortex-like magnetic structures retrieved from the typical TIE analysis of Lorentz-TEM. (b) Real features of these complex magnetic structures obtained from the differential phase contrast technique. Credit: ©Science China Press

Recently, observation of new topological magnetic structures represented by skyrmions is expected to provide new paths in constructing spintronic devices. In magnetic bubbles, although these are "ancient" cylinder domains, the type-I bubbles (renamed as skyrmion bubbles with the same topology as skyrmions) have remotivated general scientific interests. On using Lorentz transmission electron microscopy (Lorentz-TEM) to recognize magnetic bubbles in magnetic nanostructures, scientists observed some complex vortex-like magnetic structures beyond the traditional magnetic bubbles, which could be used as information carriers in emerging spintronic devices. Physical understanding of them, however, remains unclear. Recently, Tang et al. from High Magnetic Field Laboratory of Chinese Academy of Sciences clarified these complex vortex-like structures as depth-modulated three-dimensional (3-D) magnetic bubbles in a Kagome crystal Fe_3Sn_2.

As retrieved from the traditional TIE analysis technique, the magnetic configurations may deviate significantly from real magnetic structures. Because of the direct detection of the local magnetic field of the differential phase contrast (DPC) technique, DPC makes it a more advanced technique in determining real magnetic configurations accurately. Using the DPC technique, first, authors obtained the real features of these complex magnetic configurations. Then, by combining with 3-D numerical simulated types-I and II magnetic bubbles, authors further demonstrated that the integral in-plane magnetization mappings of two types of magnetic bubbles are in high consistency with the experiments and are responsible for the complex vortex-like magnetic structures.

As obtained from the TEM technique, the magnetic configurations are more readily considered as two-dimensional magnetic domains. This study suggests that 3-D magnetic structures play an important role in understanding complex magnetic configurations. Recently, 3-D magnetic structures have attracted much attention; however, direct observation of 3-D magnetic structures remains a challenging task. This study provides an important experimental proof of the existence of 3-D magnetic structures.



Numerical simulated depth-modulated two types of magnetic bubbles (upper panel) and corresponding integral in-plane magnetization mappings over the depth (bottom panel). Credit: ©Science China Press

More information: Jin Tang et al, Two-dimensional characterization of three-dimensional nanostructures of magnetic bubbles in Fe_3Sn_2, *National Science Review* (2020). DOI: 10.1093/nsr/nwaa200

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