Topological defects in hexagonal manganites: from multiferroics to cosmology

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Topological defects, such as domain walls and vortices, are pervasive in complex matter such as superfluids, liquid crystals, the earth's atmosphere, and the early universe. They have been fruitful playgrounds for emergent phenomena [1, 2]. Multiferroics are materials with coexisting magnetic and ferroelectric orders, where the cross-coupling between two ferroic orders can result in strong magnetoelectric coupling. Therefore, it is of both fundamental and technological interest to visualize cross-coupled topological defects in multiferroics. Indeed, topological defects with six interlocked structural antiphase and ferroelectric domains merging into a vortex core were revealed in multiferroic hexagonal manganites [3, 4]. Numerous vortices are found to form an intriguing self-organized network, and may be used to test Kibble-Zurek model of early universe [5]. Many emergent phenomena, such as conduction and unusual piezoelectric response, were observed in charged ferroelectric domain walls protected by these topological defects [6-8]. More interestingly, alternating uncompensated magnetic moments were discovered at coupled antiferromagnetic-ferroelectric domain walls in hexagonal manganites $ErMnO_3$, which correlate with each other throughout the entire vortex network [9]. This collective nature of domain wall magnetism originates from the uncompensated Er^{3+} moments at domain walls and the self-organization of the vortex network. Our results demonstrate that the collective domain wall magnetism can be controlled by external magnetic fields and represent a major advancement in the manipulation of local magnetic moments by harnessing cross-coupled domain walls.

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