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Real Space Observation of Helical Spin Order

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When a symmetry gets spontaneously broken in a phase transition, topological defects are routinely formed. There are numerous examples of topological defects in condensed matter systems, such as, vortices in superconductors, vortices in superfluid helium, monopoles and strings in liquid crystals, etc. A similar picture would emerge in helimagnets. It is therefore interesting to deepen our understanding of how, what kind of, and why magnetic defects form and how they evolve after formation in helimagnets. In recent years, there have been significant advances in the experiment [1] and in the theories [2] of phases and textures in helimagnets. This will have a significant impact on our understanding of not only the puzzling behavior of the helimagnet MnSi with non-Fermi-liquid transport properties [3], but also phase transitions and phase diagrams in different condensed matter systems.

In this paper, we describe the current status of our experiments. To see the helical spin order and magnetic defects in metal silicides such as (Fe, Co)Si and FeGe in real space, we used Lorentz electron microscopy, combined with the transport of intensity equation (TIE) analysis or holographic interference microscopy. This method has allowed us to find the topological defect similar to atomic dislocations in the crystal lattice. Furthermore, by applying magnetic fields, we directly observed the deformation processes of the helical spin order, accompanied by nucleation, movement, and annihilation of the magnetic defects.

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[3] C. Pfleiderer *et al.*, Nature **427**, 227 (2004).