Magnetic antiskyrmions above room temperature in tetragonal Heusler materials

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Magnetic skyrmions are topologically protected, vortex-like objects surrounded by chiral boundaries that separate a region of reversed magnetization from the surrounding magnetized material. Due to their stable configuration, small size and the possibility to move them by low electric currents, they are potential candidates for application in information storage and logical technologies. Stabilization of skyrmions has generally been achieved in systems with broken inversion symmetry, in which the asymmetric Dzyaloshinskii–Moriya interaction modifies the uniform magnetic state to a swirling state. Depending on the crystal symmetry, two distinct types of skyrmions have been observed experimentally, namely, Bloch and Néel skyrmions. Here, we present the experimental manifestation of another type of skyrmion—the magnetic antiskyrmion—in acentric tetragonal Heusler compounds with D_{2d} crystal symmetry. Antiskyrmions are characterized by boundary walls that have alternating Bloch and Néel type as one traces around the boundary. A spiral magnetic ground state, which propagates in the tetragonal basal plane, is transformed into an antiskyrmion lattice state under magnetic fields applied along the tetragonal axis over a wide range of temperatures. Mn_2YZ-based magnetic Heusler compounds (Y and Z are transition metal and main-group element, respectively) are ideal for the design of tetragonal materials with flexible magnetic configurations. The subset of Heusler compounds that have a tetragonal inverse structure also have the correct symmetry (D_{2d}) for hosting antiskyrmion phases. Here, we focus on the inverse tetragonal Heusler compound $Mn_{1.4}Pt_{0.9}Pd_{0.1}Sn$. Direct imaging by Lorentz transmission electron microscopy shows field stabilized antiskyrmion lattices and isolated antiskyrmions from 100 K to well beyond room temperature, and zero-field metastable antiskyrmions at low temperatures [1].

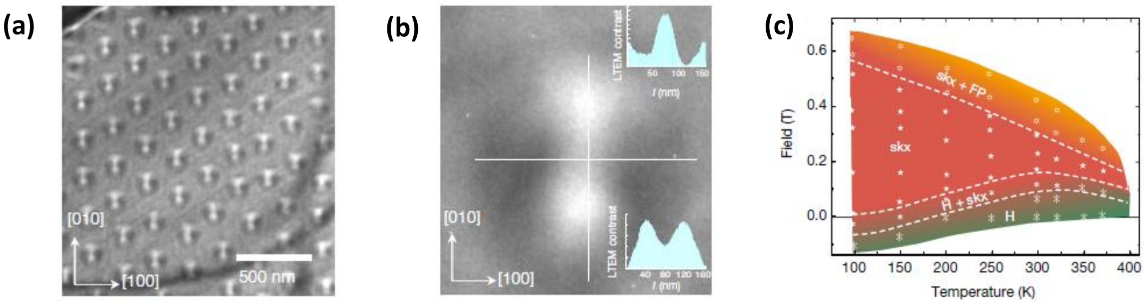

Figure. (**a)** Under-focused LTEM images of antiskyrmions taken at fields applied along [001] of 0.29 T. **(b)** A single antiskyrmion. The lower and upper insets show the intensity profiles of the in-plane magnetization along [010] and [100], respectively. The corresponding scanned regions are marked by lines. *l*, distance. **(c)** Field–temperature phase diagrams.

[1] Nayak *et al*., *Nature* **548,** 561 (2017).