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Realization and dynamics of 2D magnetic skyrmions[1]

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The skyrmion, a vortex-like topological spin texture, can be excited by the external magnetic field (B) in helimagnets [1-6]. The skyrmion lattice was recently confirmed by small-angle scattering neutron observations in a helimagnet MnSi [1] where the skyrmion phase was observed in a narrow window of (T, B)-plane. In contrast with unstable skyrmions in the bulk, by using Lorentz transmission electron microscopy (TEM), we have realized two-dimensional (2D) skyrmion crystal (SkX) over a wider region in (T, B)-plane for thin helimagnets [2-6] which thicknesses are smaller than their helical periods. Furthermore, we have realized the near RT (∼280 K) formation of SkX in a helimagnet FeGe [3]. We have clarified the stability condition for the SkX, i.e. the magnetic-dimension (from 2D to 3D) variation of SkX phase diagram in (T, B)-plane. The skyrmion acts as a magnetic flux owing to its curved spin texture. When an electric current flowing through the skyrmion exceeds a critical current density for depinning, the skyrmion can accept the spin transfer torque to be driven along the current direction. Combining electrical and magnetic control in a microdevice composed of a FeGe thin plate, we have realized nanometric skyrmions under a weak magnetic field (150 mT) and manipulated them with an ultra-low current density ($\sim 5 \times 10^4 \mathrm{A/m^2}$) [6], several orders lower than that required to drive domain walls in conventional ferromagnets [7]. This work has been done in collaboration with Prof. Y. Tokura, Prof. N. Nagaosa, Dr. Y. Matsui, Prof. Y. Onose, Mr. N. Kanazawa, Dr. K. Kimoto, Dr. T. Hara, Dr. T. Nagai, and Ms. W-Z. Zhang.

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