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Controlling Skyrmion Lattice Dynamics with Thermal and Magnetic Field Gradients

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Magnetic skyrmions exhibit a rich landscape of dynamical behavior shaped by their topological character and collective organization. In this work, we explore the motion of skyrmion lattices in chiral magnets under two orthogonal driving mechanisms: magnetic field gradients [1] and thermal gradients [2,3]. Using resonant elastic x-ray scattering (REXS) on Cu_2OSeO_3, we demonstrate how finite-sized skyrmion lattices respond to these drives not only by translation, but also by rotation, undergoing a coherent rolling motion driven either by magnon flow (in thermal gradients) [2] or by field-induced torques [1]. The rotational sense and velocity scale predictably with gradient strength and crystallite size, revealing the emergence of a chiral lattice torque, also allowing for the direct measurement of the skyrmion Hall angle in the lattice state [4]. To access the three-dimensional nature of skyrmion textures, we complement these surface-sensitive studies with small-angle neutron scattering (SANS) experiments on MnSi [3]. There, we uncover depth-resolved bending of skyrmion strings under two-dimensional thermal gradients, driven by a temperature-dependent skyrmion Hall effect and governed by a modified Thiele equation incorporating magnon friction. This dual approach, combining high-resolution REXS at the surface and SANS through the bulk, offers a unified view of skyrmion lattice dynamics and demonstrates new modalities for manipulating topological spin textures in three dimensions.

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