Skyrmion Lattices in Random and Ordered Potential Landscapes

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Since the initial discovery of skyrmion lattices in chiral magnets [1], there has been a tremendous growth in this field as an increasing number of compounds have been identified with extended regions of stable skyrmion lattices [2] even close to room temperature [3]. These systems have significant promise for applications due to their size scale and the low currents needed to move the skyrmions [4]. Another interesting aspect of skyrmions is that their equations of motion contain a significant non-dissipative or Magnus term, making skyrmions unique among systems exhibiting collective driven dynamics and distinct from vortex lattices in type-II superconductors, sliding charge density waves, or frictional systems. We examine the driven dynamics of skyrmions interacting with random and periodic substrates using both continuum based modeling and particle-based simulations. In clean systems, we study the skyrmion motion as a function of magnetic field and current, and show that current-induced creation or destruction of skyrmions can occur. When random pinning is present, we find a finite depinning threshold and demonstrate that the Hall angle depends strongly on the disorder strength. We correlate features in the transport curves with different skyrmion flow regimes, including skyrmion glass depinning, skyrmion plastic flow, and a transition to a dynamically reordered skyrmion crystal at high drives. We find that increasing the Magnus term depresses the depinning threshold due to a combination of skyrmions undergoing complex orbits within the pinning sites along with skyrmion-skyrmion scattering effects. For skyrmion motion over a periodic substrate, as the drive increases, the Hall angle changes in quantized steps that correspond to periodic skyrmion trajectories that lock to symmetry directions of the substrate potential.

References

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