Enhanced diffusion in skyrmion lattices

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Skyrmions have been proposed as the foundation of many novel technological advances such as the possibility of creating racetrack memories or realizing probabilistic computing technologies. Implementations of these concepts need to be realized at finite temperatures causing potential diffusion of any present skyrmions. Skyrmion diffusion has been explored in the past [1, 2, 3], with one important result being that the diffusion of the skyrmions is suppressed by the nontrivial topology of the skyrmion itself [1]. These results, however, are based on calculations for free diffusion. In implementations of technologically novel concepts, skyrmions may interact either with external potentials such as system boundaries, or with each other. Counterintuitively, this does not result in a further diminishing of the diffusive behavior, as we will show.

We use molecular dynamics simulations, solving the Thiele equation [4] numerically, using Parameters determined for $(Pt_{0.95}\ Ir_{0.05}\ )$/Fe on a Pd(111) surface [3]. We use simple effective skyrmion-skyrmion interaction potentials to model skyrmion lattices. By this approach, it is possible to compare solutions for skyrmions trivial and non-trivial topology, by including or omitting the cor- responding term in the equation of motion. Therefore we can attribute any observed effect to the topology of the skyrmions. In skyrmion lattices, we observe a lifting of the topological suppression of diffusion, resulting in an enhanced skyrmion diffusion compared to free diffusion. The strength of the suppression of diffusion is determined by multiple factors, including the spin damping constant present in the Landau-Lifshitz-Gilbert equation. Lower values of the damping cause a stronger suppression of diffusion in free diffusion but also enables a stronger lifting of this suppression. Another important factor in the lifting of topological suppression is the strength of the potential applied to each skyrmion. Varying the strength of the potential can be achieved by using different skyrmion lattice densities. The result of such a simulation shows an increase of diffusion with increasing the skyrmion density for low densities (see FIG 1).

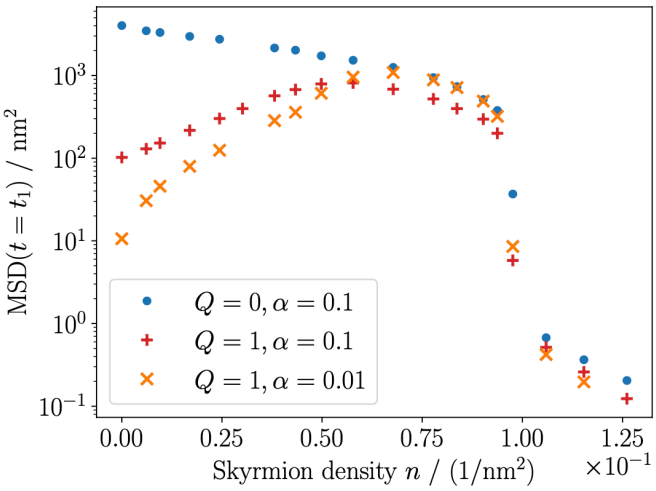

Fig. 1: *Skyrmion diffusion with and without topological charge as a function of skyrmion density n.*

References:

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