Spin Dynamics in Cubic Skyrmion Materials

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Abstract

The discovery of a new topological form of magnetic order in the family of cubic Dzyaloshinskii-Moriya helimagnets has recently attracted increasing scientific interest. This new magnetic state consists of a lattice of skyrmions, i.e., magnetic vortices characterized by a topological winding number. This implies that skyrmions represent topologically-protected magnetic particles with a skyrmion radius $\xi$ that is a mesoscale length scale and typically of the order of 10-200 nm. The mesoscale size together with their topologically protected nature makes them insensitive to atomic-scale defects and impurities and enables them to move independently from the underlying crystal structure. In particular, it has been shown that ultralow current densities of $10^6$ A/m$^2$ allow moving skyrmions through a material via the spin-torque effect. Moving conventional spin-textures such as domain walls requires six orders of magnitude higher currents. Together with the ability to create and delete individual skyrmions via current pulses or polarized spin-currents these novel spin textures have unprecedented potential for low-power/high-density non-volatile racetrack memories and spintronics. Controlling the skyrmion size $\xi$ is critical for creating future applications based on these spin-textures; for example, for memory devices, small size $\xi$ (high memory density) is required. However, too small of a size will make skyrmions more susceptible to microscopic defects, and therefore less mobile, requiring larger currents to move them. To first order, $\xi$ is controlled by two competing magnetic interactions, namely ferromagnetic exchange and the Dzyaloshinskii-Moriya interaction. Here we will report on our extensive neutron scattering studies that reveal the spin dynamics and the underlying magnetic interactions of the prototypical skyrmion compound MnSi.