

## **Skyrmions: SANS, NSE and $\mu$ SR**

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Topological defects or solitons are irregularities which occur within continuous fields or ordered states of matter. These defects (points, lines, or surfaces) are characterised by their stability and the fact that they cannot be ‘smoothed out’ or removed through continuous transformations. In particle physics, the Skyrmion is a topologically stable field configuration originally proposed to describe the nucleon. In solid state physics, crystalline materials without inversion symmetry exhibit a variety of exotic magnetically ordered states with canted spin structures like helices, conical states or a periodic array of “Skyrmions”, a swirling topologically nontrivial spin structure.

The role of muon spin relaxation ( $\mu$ SR) and neutron scattering in revealing the rich magnetic phase diagram of cubic chiral magnets like MnSi is discussed. This material hosts single Bloch-type skyrmions resulting from competing or “magnetically frustrated” exchange and Dzyaloshinskii-Moriya interactions. Small angle neutron scattering (SANS) has shown that Skyrmion formation may be controlled by an applied magnetic field. This is akin to defining 0 and 1 bits, making skyrmion hosting materials candidates for applications in data storage and structure.

On a fundamental level, a knowledge of the spin excitations in canted spin systems, including chiral fluctuations, is crucial, since they are defined by the magnetic interactions within the system. Boundaries and confined geometries will markedly influence this spin fluctuation spectrum. Thermal fluctuations stabilise the Skyrmion phase in only a very small precursor phase in bulk samples. Intrinsically, interfaces break inversion symmetry, leading to greatly enhanced stability of Skyrmion phases in thin films, for reasons which are under research.

The spin dynamics associated with a lattice of Skyrmions are challenging to measure at the microelectronvolts energy scale at small wavevectors needed. The landscape of complementarity between various large scale facility based experimental techniques like small angle neutron scattering (SANS), neutron spin echo (NSE) and  $\mu$ SR will be described, using MnSi as a rewarding example. Some of these techniques are part of the infrastructure within the Centre for Molecular and Materials Science at TRIUMF. Others constitute a wish list for future Canadian accelerator based neutron sources.

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