New Materials for Skyrmions at Room Temperature

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In a conventional magnetic material, the spins on neighbouring atomic sites are collinear, due to the scalar product form of the Heisenberg exchange interaction. In principle, vector cross product interactions, called Dzyaloshinkii-Moriya interactions (DMI), are possible, which will attempt to align neighbouring spins at right angles. Most crystal structures have spatial inversion symmetry and under these circumstances DMI interactions at a given atomic site cancel exactly. However, there are lattices that lack inversion symmetry, and in that case chiral magnetic structures arise. Of particular interest are magnetic skyrmions, particle-like twists in the magnetization that have fascinating spintronic properties. They give rise to a so-called topological contribution to the Hall effect, and are very easily moved by the flow of spin-polarised electrons, suggesting the possibility of ultra-low power skyrmion-based spintronic devices such as racetrack memories.

Until this year all known materials that support skyrmions are only magnetic below room temperature. The sole exception are very large (> 1 micron) skyrmionic bubbles in ultrathin (< 1 nm) magnetic films [1]. In the summer of 2015, the discovery was made that β-Mn structure CoMnZn alloys, which have a chiral crystal lattice, can support skyrmions at and above room temperature [2]. So far, only bulk crystals of this material have been studied, but to realise technologies, thin films from which devices can be fabricated using the conventional planar processing techniques of microelectronics manufacturing are required. In this project we will address this gap by growing the first thin films of these materials, studying their magnetic phase diagram, and seeking to control the presence of room-temperature skyrmions through a mixture of magnetotransport, magnetisation dynamics, and high resolution imaging experiments.

This project may offer the prospect of collaboration with the electron microscopy group in the Institute for Materials Research in Leeds and the UK’s world-leading pulsed neutron source, ISIS.