Skyrmions at Chiral Magnetic Interfaces

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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, chiral vector cross product interactions, called Dzyaloshinkii-Moriya interactions (DMIs), are possible when spin-orbit coupling is present, 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.

Even if it is not built into the crystal lattice, inversion asymmetry exists at any surface or interface, and so a DMI can be found there even in a conventional magnetic material. Skyrmion formation has recently been observed by a handful of labs globally (including Leeds) in ultrathin (< 1 nm) magnetic films that have interfaces with heavy metals that give the required strong spin-orbit effects. In this project we will refine these systems to enhance the interfacial DMI and seek the presence of room-temperature skyrmions through a mixture of magnetotransport, magnetisation dynamics, and high resolution imaging experiments.