doi:10.1017/S1431927622006791
Microsc. Microanal. 28 (Suppl 1), 2022

Magnetic Signature in a Topological Kagome Magnet

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The exploration of quantum topology under non-trivial lattice geometry and strong electron interaction is emerging as a new frontier in condensed-matter physics that not only has analogies with high-energy physics but also expands the range of quantum materials available for next-generation technology [1-3]. Recently, the transition-metal-based kagome magnets have attracted great attention, as they often show correlated topological band structures. A kagome lattice, made of corner-sharing triangles, naturally has relativistic band crossings at the Brillouin zone corners. The inclusion of spin–orbit coupling and out-of-plane ferromagnetic ordering in the kagome lattice effectively realizes the spinless Haldane model by generating Chern gapped topological fermions.

$ReMn_6Sn_6$ is a key advance in quantum materials. Unlike other members of the kagome magnet family, it consists of segregated kagome layers formed purely by manganese atoms. More crucially, its kagome lattice uniquely features both an out-of-plane magnetization ground state and the largest coercivity (1.1 T) within the RMn6Sn6 family [1].

In this report, we focused on $TbMn_6Sn_6$ and detailed its microstructure and the magnetic signature via electron microscopy and magnetic force microscopy. As shown in Figure 1, $TbMn_6Sn_6$ has a layered crystal structure with space group P6/mmm and hexagonal lattice constants a = 5.5 Å and c = 9.0 Å. It consists of a manganese kagome layer with tin and terbium successively distributed in alternating layers stacked along the c axis. The material has a ferrimagnetic ground state (Curie temperature, T_C = 423 K), with a manganese moment of 2.4 Bohr magnetons (μB) ferromagnetically aligned along the c axis and a terbium moment of 8.6μB anti-aligned along the c axis. Based on atomic resolution STEM imaging (Figure 1c), we observed a link between Tb and Mn/Sn columns (no beam irradiation issue [4]) which indicated an interplay between incident electrons and internal magnetic field around atoms. We further explored the surface domains of thin lamellar $TbMn_6Sn_6$ samples which helped us to figure out its intrinsic magnetic properties [5].

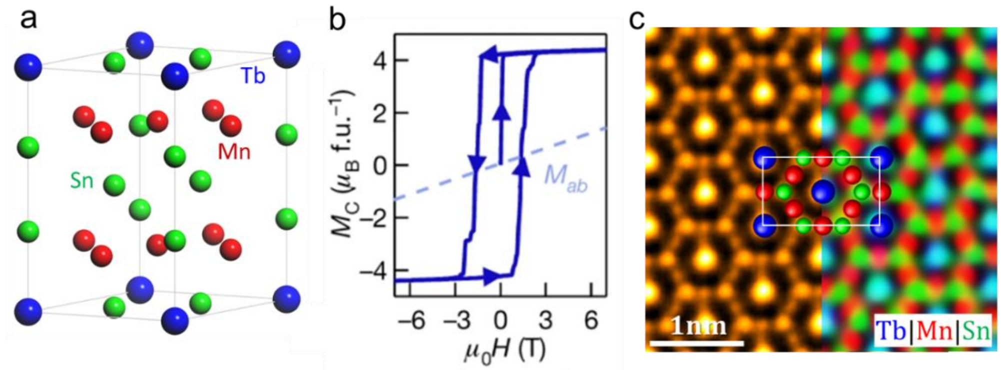

Figure 1. a, An atomic model of $TbMn_6Sn_6$ unit cell. **b,** The out-of-plane (solid lines) and in-plane (dashed lines) magnetization curves taken at 4.2 K. 'f.u.' denotes the formula unit. **c,** In-plane (zone axis, [0001]) atomic-resolution image and elemental mapping of $TbMn_6Sn_6$ taken by a scanning transmission electron microscope with an energy dispersive X-ray detector.

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https://doi.org/10.1017/S1431927622006791 Published online by Cambridge University Press