Powder neutron diffraction on topological magnets

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Powder neutron diffraction remains one of the most powerful techniques for determining magnetic structures. While its success in solving simple ferro- and antiferromagnetic arrangements has been established since the pioneering neutron diffraction studies of the late 1940s, modern magnetic materials present significantly greater challenges. Topological magnets exhibit non-collinear and non-coplanar spin textures associated with multiple propagation **k**-vectors and complex symmetry relations, whose determination requires a combination of diffraction experiments and symmetry analysis.

In this talk I will discuss how developments of magnetic space-group and superspace-group formalisms, representation analysis, crystallographic databases, and powerful software tools such as the ISOTROPY Software Suite and the software on the Bilbao Crystallographic Server have transformed the way magnetic structures are determined from neutron diffraction data. Together, these advances provide a symmetry-guided framework for solving increasingly complex magnetic structures.

The discussion will be based on our recent studies of the topological magnets MnGe and CeAlGe. They host three- and two-dimensional topological spin textures described by multi-**k** magnetic structures in magnetic superspace groups [1,2]. These examples demonstrate how powder neutron diffraction, when combined with symmetry analysis and complementary experimental information, can provide detailed insight into topological magnetic properties, including the determination of topological charge distributions from the resulting spin textures.

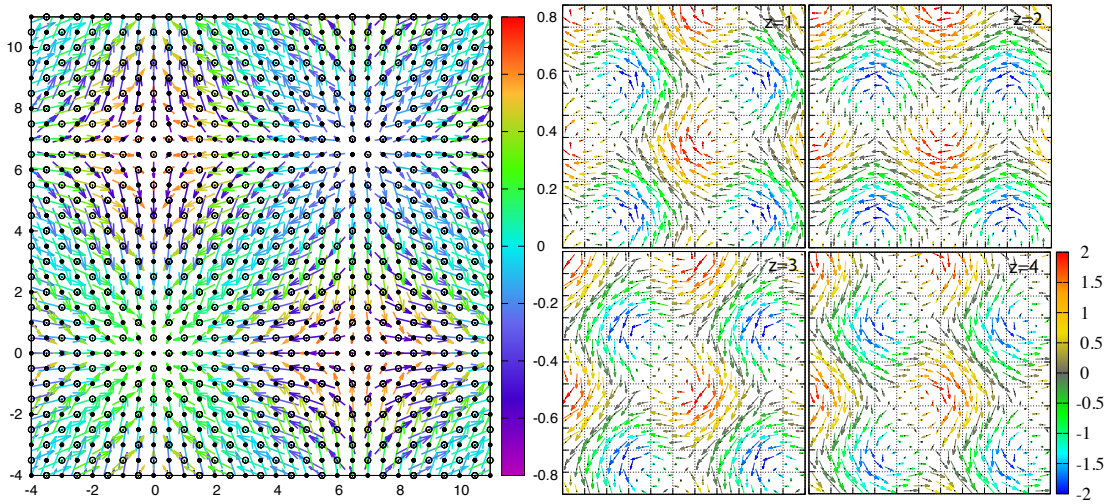


Figure 1. *Examples of topological magnetic structures determined from powder neutron diffraction data. Left: experimentally refined 3+2 skyrmion magnetic structure of CeAlGe [2]. Right: cubic 3+3 hedgehog structure of MnGe [1] shown as projections of selected z layers. Color indicates the out-of-plane magnetic-moment component.*

[1] V. Pomjakushin, I. Plokhikh, J. S. White, Y. Fujishiro, N. Kanazawa, Y. Tokura and E. Pomjakushina, Phys. Rev. B 107, 024410 (2023).

[2] V. Pomjakushin, A. Podlesnyak, P. Puphal, S. Shin, J. S. White and E. Pomjakushina, Phys. Rev. B 112, 094457 (2025).