Magnetic structure analysis of antiferromagnets hosting giant emergent magnetic field

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In recent years, altermagnet has emerged as a new class of collinear magnetism that is distinct from ferromagnets (FMs) and conventional antiferromagnets (AFMs). This new magnetic state is characterized by zero net magnetization in real space, but exhibits time-reversal symmetry breaking (TRS) in the electronic structure, resulting in non-relativistic spin splitting. For spintronics, altermagnets combine the advantages of FMs, such as spin-split bands, with the advantages of AFMs, such as zero net magnetization, lack of stray fields, and ultrafast dynamics. Due to the scarcity of altermagnets with magnetic domain controllability at room temperature, the practical application of altermagnets remains a major challenge. In particular, intermetallic compound materials that are capable of magnetic domain control near room temperature and stable in air are extremely rare. The scarcity of practical materials that allow domain control at room temperature and are stable in the air is a major barrier to moving altermagnets from basic research to technological applications.

Here, we have discovered a new intermetallic altermagnet material, MnPtAl, that allows domain control near room temperature. This discovery directly addresses the urgent need for altermagnet materials that operate at room temperature and are stable in air. In this study, we investigated its magnetic structure through neutron experiments.

With JRR-3 5G-PONTA, we measured the (*H* 0 *L*) reflection and (*H H L*) reflection. Figure 1 shows the temperature dependence of the (0 0 1) reflection intensity, which is a magnetic reflection, and the rise of antiferromagnetic order can be confirmed below the magnetic transition temperature (291 K).

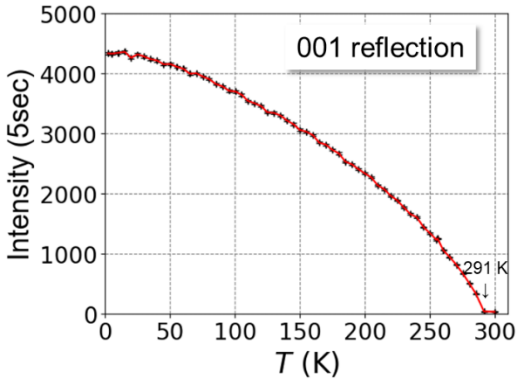

Fig. 1. Temperature dependence of the (0 0 1) reflection intensity in MnPtAl

The magnetic structure of MnPtAl was estimated from the obtained reflection intensities. Figure 2 shows the calculated magnetic structure (easy-plane simple antiferromagnetic structure) and a comparison of the corresponding calculated and measured F factors. As shown, the two agree very well, indicating that the magnetic structure of this material is a collinear antiferromagnetic structure. This result supports the fact that MnPtAl has properties as an altermagnet, and is an important result for conducting basic research on this material.

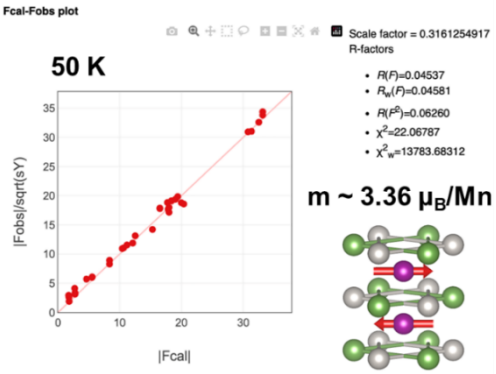

Fig. 2. Fitting of magnetic structure in MnPtAl