Nuclear-Magnetic Interference in Altermagnet MnTe

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Antiphase domain states in conventional collinear antiferromagnets are identical in the reciprocal space when spin-orbit coupling is absent, and are thus only detectable in the real space. By contrast, due to the spontaneous time-reversal symmetry breaking, antiphase domain states in altermagnets are distinguishable even in reciprocal space [1–3]. For neutrons scattered by both the ordered electron spins and nuclear ligands in altermagnets, the observable manifests itself as nuclear-magnetic interference (NMI) terms, which alter their sign between antiphase domain states. In this study, polarized neutron diffraction was performed on the altermagnetic prototype MnTe on 5G-PONTA at JRR-3 to observe the NMI terms. Single crystal of MnTe with mass 1.24 gram was aligned in the scattering plane $(h0l)$. The experiments were performed in the half-polarized mode, where the spins of incident beam are polarized by Heusler crystal array and flipped by a flipper, while the spins of final beam are not analyzed. A pair of vertical and three horizontal Helmholtz coils are installed at the sample position to generate the guide field as well as the cooling field along arbitrary directions. Because a balanced magnetic antiphase domain distribution leads to zero NMI signal, the sample with imbalanced domain distribution was prepared by field cooling (FC) along the c-axis from 330 K to 100 K.

In MnTe, the NMI effect happens where the nuclear Bragg peaks coincide with magnetic Bragg peaks, such as (101), (103), (201), and (203) positions. Besides, for a collinear antiferromagnetic spin structure, the NMI term is proportional to the averaged Néel vector in the sample. After FC in milli-Telsa magnetic field, we observed pronounced NMI terms at the expected positions. In contrast, the signal is absent after zero field cooling, suggesting a balanced domain distribution. Figure 1 shows the φ-scans (two-theta scans) of NMI term R_z measured by the z-polarized neutrons at (101) after FC in various field strength. The NMI intensities monotonically decease with the decreasing of cooling field strength, and reverses their signs with the field direction. The averaged unit Néel vector $\bar{\hat{n}}$ was obtained from the observed NMI terms and mapped in the ab-plane, as shown in Fig. 1(b), indicating the control of magnetic antiphase domain by FC technique in altermagnet.

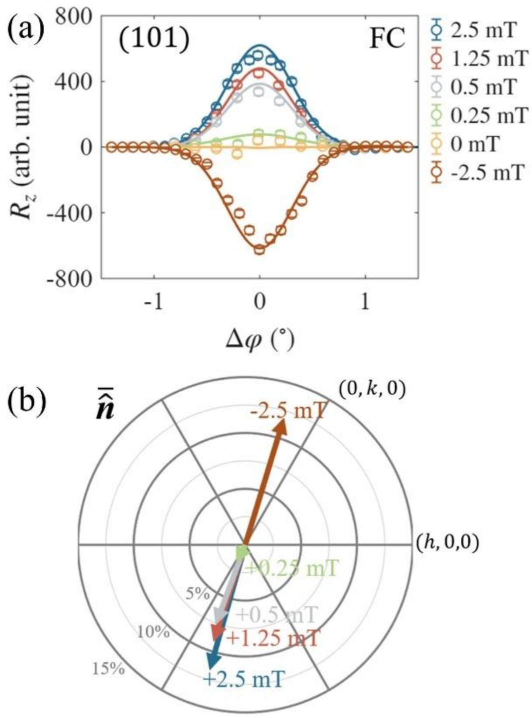

Fig. 1. (a) Cooling-field dependence of NMI term R_z at Bragg peak (101) at 100 K. (b) Mapping of the averaged unit Néel vector $\bar{\hat{n}}$ after each cooling condition in the ab-plane.

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