Observation of the Stability of Topological Properties in Ilmenite $NiTiO_3$

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The importance of topology in condensed matter physics has been widely recognized with the synthesis of graphene and the discovery of topological insulators [1]. In such materials, unique metallic states appear at the edges, and anomalous transport phenomena are explained by massless Dirac fermions. These phenomena can be extended not only to fermionic systems but also to bosonic systems [2]. For the ilmenite $CoTiO_3$, the presence of topological magnons has been proposed based on inelastic neutron scattering (INS) experiments, and it has been suggested that their stability is maintained even under perturbations [3]. Therefore, to discuss the presence and stability of these topological magnons in $NiTiO_3$, which has the same crystal and magnetic structure as $CoTiO_3$ [4], we conducted INS experiments using HODACA spectrometer [5] installed at JRR3/C11.

A single crystal of 1.2 g grown by the floating zone (FZ) method was used, and the a^*-c^* plane was measured. Figs. 1(a) and (b) show the INS spectra along the (h,0,1.5) and (0,0,l) directions, respectively. In Fig. 1(a), an acoustic mode originating from the magnetic propagation vector $\boldsymbol{q}$ = (0,0,1.5) was observed up to 3.7 meV. Fig. 1(b) shows an acoustic mode with a band energy of 2.5 meV. Since this is approximately 2/3 of the band energy along the a^* direction, it indicates that the material has significant interactions along the c-axis, suggesting that this is a three-dimensional magnetic system. A flat optical mode was observed at 3.7 meV, reflecting the band energy along the a^* direction. Furthermore, a gap excitation was observed at 1 meV, which suggests easy-plane anisotropy. The rise of the acoustic mode from (0,0,1.5) indicates that the material has antiferromagnetic correlations along the c-axis, considering the ABC-stacked honeycomb lattice, consistent with the magnetic structure determined by neutron diffraction experiments.

Based on these results, the spin Hamiltonian parameters were determined. Figs. 1(c) and (d) show the calculated INS spectra using the determined parameters, which reproduce the experimental results. The calculations confirmed the existence of topological magnons in $NiTiO_3$, similar to $CoTiO_3$. Furthermore, it was demonstrated that these topological magnons remain stable even when weak further-neighbor interactions are included.

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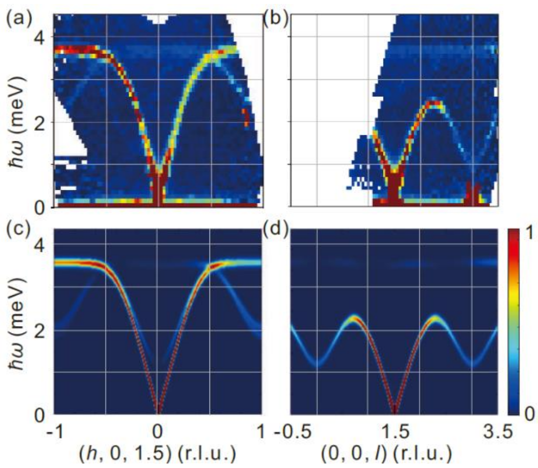

Fig. 1. (a), (b) Inelastic neutron scattering spectra measured at T = 2.3 K using HODACA spectrometer. (a) shows the (h,0,1.5) direction, and (b) shows the (0,0,l) direction. (c), (d) Inelastic neutron scattering spectra calculated using linear spin-wave theory. (c) shows the (h,0,1.5) direction, and (d) shows the (0,0,l) direction.