Study of magnetic excitations of spin chain material Tb_3RuO_7 to which staggered internal magnetic fields are applied

M. HASE[A], K. Nawa[B], D. Okuyama[B,C], T. J. Sato[B], S. Asai[D], T. Masuda[D]

[A]NIMS, [B]IMRAM, Tohoku Univ., [C]KEK, [D]ISSP-NSL, Univ. of Tokyo

The magnetic structure of Tb_3RuO_7 is unique [1]. We carried out inelastic neutron scattering (INS) experiments on Tb_3RuO_7 powder using 4G GPTAS to obtain magnetic excitations.

We observed the crystal-field excitations of Tb^{3+} ions at ω > 13 meV and the spin-wave excitations at ω < 8 meV. Figure 1 depicts neutron scattering intensity $I(Q,\omega)$ at 2.4 K (a) and 20 K (b). We can see excitations at ω < 8 meV and only low Q, indicating that the excitations are not crystal-field excitations. Dispersions of the excitations seem to exist at 2.4 K (< T_N = 17 K), whereas those become blurred at 20 K. Therefore, the excitations are spin-wave excitations. The excitation energy at 2.4 K seems lowest at around Q = 1.25 $Å^{-1}$ that is close to the position of the largest magnetic reflection (Q = 1.22 $Å^{-1}$) [1]. The largest magnetic reflection is generated by ordered Tb magnetic moments. Magnetic reflections by Tb moments are much larger than those by Ru moments. The energy of the spin-wave excitations is proportional to magnitude of interaction between magnetic moments and that of magnetic moments. We infer that the large Tb moments can generate the excitations up to 8 meV. Accordingly, we consider that the spin-wave excitations mainly originate in Tb moments.

A model based on ferromagnetic (FM) spin chains may be explainable for the INS results of the Tb_3RuO_7 powder. Q = 1.22 $Å^{-1}$ corresponds to $Q_{1D} = 2\pi/d$. The value of d is evaluated to be 5.15 Å. FM interactions are expected between Tb3 and Tb5 moments and between Tb4 and Tb6 moments in the direction nearly parallel to the c axis. The Tb3-Tb5 and Tb4-Tb6 lengths are 5.81 and 4.76 Å, respectively, and the average is 5.28 Å. Unlike AFM chains, the intensity of the dynamical structure factor [$S(Q_{1D},\omega)$] is independent of Q_{1D} in FM chains. Therefore, the spin-wave excitations are visible in wide Q and ω ranges in powder-averaged intensity like the results shown in Fig. 1(a).

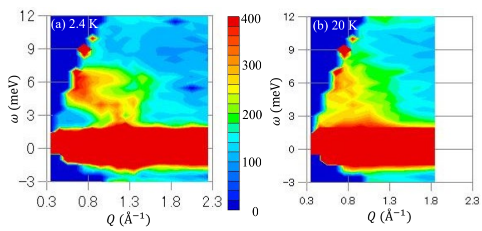

Fig. 1. $I(Q,\omega)$ of Tb3RuO7 powder at 2.4 K (a) and 20 K (b). The final neutron energy is E_f = 13.7 meV.

Accordingly, a model based on FM spin chains may be able to explain the INS results of the Tb_3RuO_7 powder.

[1] M. Hase, A. Dönni, and V. Yu. Pomjakushin, Phys. Rev B 104, 214430 (2021).