Observation of spin dynamics in Shastry- Shutherland lattice TbB4

K. Ohoyama, T. Matsumura(A), D. Okuyama(A), F. Iga(B), S. Michimura(B)
IMR, Tohoku Univ., Faculty Science, Tohoku Univ.(A), ADSM, Hiroshima Univ.(B)

Rare earth compounds RB4 have attracted our interests because the geometrical alignment of the rare earth ions in the c-plane is equivalent with that of the Shastry-Sutherland lattice in which magnetic frustration is theoretically predicted. Of this system, TbB4 reveals successive magnetic transitions at TN1=42.1K and TN2=21.7K. An important characteristic point of TbB4 is that, in magnetization process for B//[001], TbB4 shows 9-steps metamagnetic transitions between 15T<H<30T below TN2, even though the magnetic structure under B=0T is an Heisenberg type antiferromagnetic one: all the magnetic moments below TN2 lies in the c-axis. The metamagnetic transitions in a Heisenberg-type magnet imply some unknown magnetic properties in RB4.

To understand magnetic properties in TbB4, it is indispensable to understand 4f ground state and low-lying 4f levels. Therefore, we are systematically investigating magnetic excitations in TbB4 under zero magnetic field. In 2007, we performed neutron inelastic scattering experiments on a single crystalline sample of Tb11B4 on 6G and T1-2, and found some characteristic behaviour of spin dynamics around the transition temperatures. The collimation condition were B-30-S-PG filter-30-B to obtain higher resolution. The constant Ef mode was selected with kf=2.67A-1.

Fig.1 shows the temperature dependence of energy spectra of TbB4 observed on 6G at the (100) reciprocal lattice point which corresponds to the magnetic zone centre. As shown in the figure, a magnetic excitation was observed at about 3meV at T=60K; the excitation energy decreases down to 1.5meV with decreasing temperature (top figure); the excitation can not be distinguished from the elastic scattering around TN2 under present resolution condition (middle figure). On the other hand below TN2, the excitation rapidly change the position to about 2meV and increases with decreasing temperature (bottom figure). This suggests that some kind of softening of excitation occurs above TN2. Furthermore, since the excitation energy near TN2 is smaller than the thermal energy, some quasi-degeneracy may play an important role for the magnetic properties in TbB4. To clarify the bahaviour of the low-lying 4f states around TN2, higher resolution experiments are in progress.

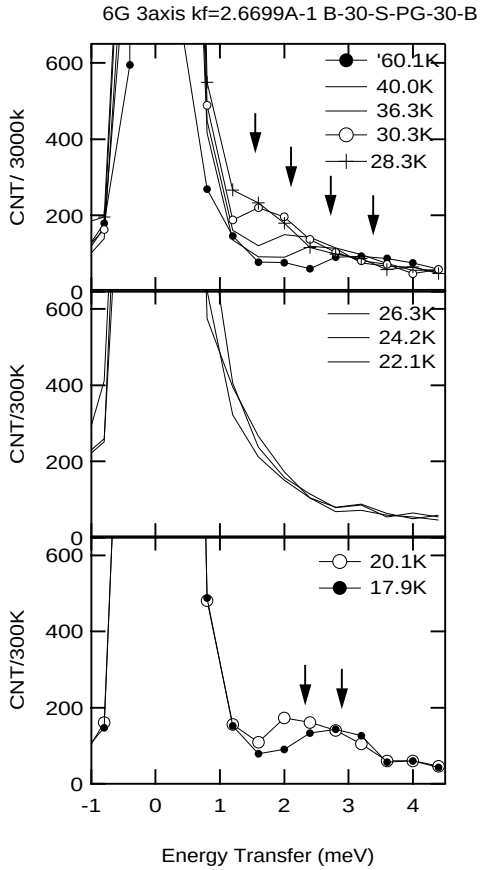

Fig. 1. Energy spectra of TbB4 observed on 6G at several temperatures at the (100) reciprocal point. Top: T>TN2, Middle: near TN2, Bottom: T<TN2