Spin-lattice dynamics in rare earth antiferroquadrupolar ordering conpound HoB2C2

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The RB2C2 (R=rare earth) compounds, which have the tetragonal LaB2C2 type structure with P4/mbm symmetry, show diversified magnetic properties caused by coexistence of antiferroquadrupolar (AFQ) and antiferromagnetic (AFM) interactions. In particular, DyB2C2 is the first tetragonal rare earth compound in which an AFQ ordering is realised. Since the exact ground state by crystalline electric field under tetragonal symmetry has no degree of freedom on electric quadrupolar moments, it was thought that no AFQ ordering can be realised in the tetragonal rare earth compounds.

On the contrary, we have proved that some of RB2C2 are AFQ ordering compounds with higher TQ than other typical AFQ compounds. Thus, to understand necessary conditions of AFQ orderings in rare earth compounds, it is indispensable to clarify characters of the AFQ ordering in RB2C2. Of the RB2C2 system, HoB2C2 is particularly unique because of the following points: (i) the AFQ ordering in HoB2C2 is realised at TQ=4.5K below the magnetic ordering temperature, TN=5.9K[2], (ii) anomalous magnetic diffuse scattering is observed above TQ up to 2TQ[3].

To understand the magnetic properties of HoB2C2 around the transition temperatures, we think clarifying spin-lattice dynamics is indispensable because magnetism and lattice is strongly coupled though the strong LS coupling. Therefore, we performed inelastic scattering experiments to observe higher energy excitations on 6G, and low-energy excitations on C1-1. In 2007, we succeeded in observing dispersion relations of some modes of magnetic excitations below 4meV in the ordered state. Figure 1 shows dispersion relations from the (100) to (101/2) reciprocal position at T=1.56K observed on C1-1. We found two magnetic modes at about 3meV and 0.8meV at the zone centre (100). The lower excitation shows obvious dispersion, while the dispersion of the higher mode is relatively weak. We also observed dispersion relations along the a*-direction.

From the temperature dependence of the magnetic excitation spectra, we confirmed that the lower mode becomes weak near the transition temperatures, and disappears above the transition temperatures, indicating that the lower dispersive mode is important for the AFQ and AFM ordering in HoB2C2.

References

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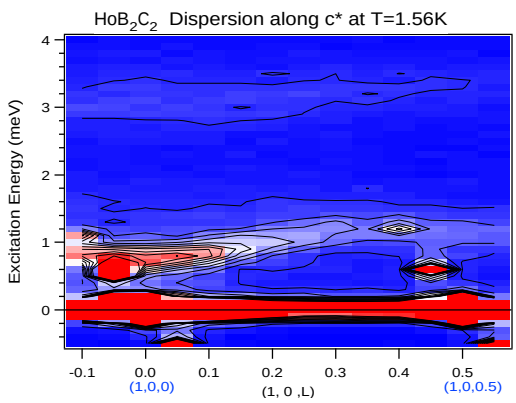

Fig. 1. Dispersion of magnetic excitations along the c* direction in HoB2C2 at T=1.56K