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Magnetic Correlation of HoB_4 with Geometrical Frustration

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Introduction

A tetragonal rare-earth compound system of RB_4 has been attracting growing interest as a system where both the quadrupolar and magnetic degrees of freedom are active in the geometrically frustrated lattice, which is equivalent to the Shastry-Sutherland lattice. We reported on the short-ranged magnetic correlation in DyB_4 last year. We observed a broadened peak profile of the resonant x-ray scattering from DyB_4 in the intermediate phase where the quadrupolar moments are considered to be fluctuating [1]. In order to compare the result with HoB_4, which exhibits similar phase transitons as in DyB_4 at T_{N1}=7.5 K and at T_{N2}=5.9 K, we have performed resonant x-ray scattering experiment on HoB_4. It has already been established by neutron diffraction that an incommensurate magnetic order takes place at T_{N1} and a first-order-like phase transition at T_{N2} into a commensurate structure described by $\boldsymbol{q}$=(100).

Results, Analysis, and Discussion

Resonant x-ray scattering experiment has been performed at BL16A2 using a liquid He cryostat and the (1 0 0) forbidden reflection has been investigated in detail. Polarization analysis was carried out because the magnetic scattering arises on the σ-π' process. Azimuthal angle is defined to be zero when the c-axis is parallel to the scattering plane. Measurements were performed below T_{N2} and in the paramagnetic phase above T_{N1}. Figure 1 shows the energy dependence of the intensity of the (1 0 0) reflection. Strong magnetic reflection was observed at around Ψ=90°, while it was weak around Ψ=0°. This result is opposite to DyB_4, where the intensity was strong at around Ψ=0° and weak around Ψ=90°. At T=9.0K and Ψ=6° is the ATS scattering due to the anisotropy of the local symmetry of Ho.

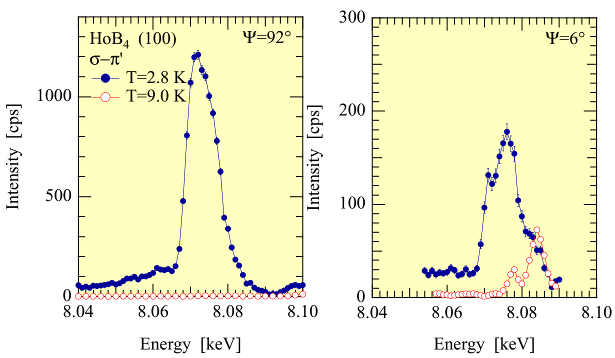

Figure 1: X-ray energy dependences of the resonant scattering intensity for the (1 0 0) reflection of HoB_4 at two azimuthal angles near 0° and 90°.

Figure 2 shows the peak profiles of these resonant peaks at E=8.072 keV, which corresponds to the energy for the E1 transition process. The profiles are slightly broader than the resolution only in the region of the tails. When we analyze the peak shape in detail, the peak profile at Ψ=92° can be well fitted with a Lorentzian. Although the profile at Ψ=6° is not symmetric because of the crystalline mosaic, it may also be regarded as a Lorentzian. A similar broadening was also observed in neutron diffraction, which we consider to be due to a short-ranged domain structure of the magnetic structure within the c-plane. The reason that the intensity at Ψ=90° is much stronger than that at Ψ=0° may be that the c-plane magnetic component in HoB_4 is much larger than that of DyB_4.

In the intermediate phase of DyB_4, the peak profile at Ψ=90° was apparently borader than the resolution, while that at Ψ=0° was as sharp as the resolution. We have interpreted the result by comparing with a model calculation that the resonance at Ψ=90° is due to the magnetic component within the c-plane or the <Ozx>-type quadrupolar moment. However, in HoB_4, since the system enters into the ordered phase with lattice distortion through a first-order transition, no such broadening is observed as in DyB_4 that reflect the fluctuating quadrupolar moments.

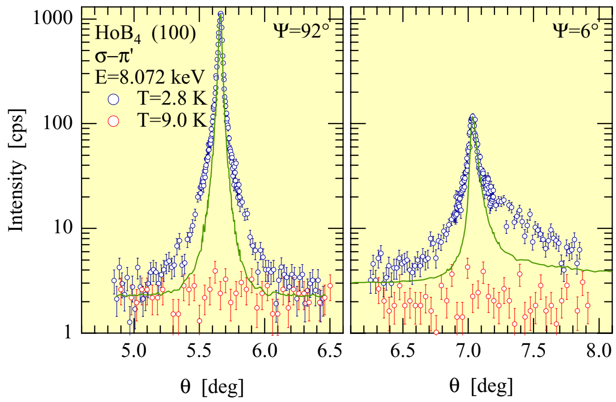

Figure 2: Peak profile of the resonant scattering for the (1 0 0) reflection at two azimuthal angles. Solid lines are the resolution functions expected from the (2 0 0) fundamental reflection.

References

[1] D. Okuyama et al., J. Phys. Soc. Jpn., **74**, 2434 (2005).

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