4C, 16A2, 1B/2002G054

Magnetic structure and lattice distortion of GdB_6

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Introduction

GdB_6 undergoes two successive phase transitions at T_N = ~15 K and T^* = ~10 K [1]. From the previous x-ray scattering experiment [2], the lattice distortions at [0 0 1/2] and [1/2 1/2 0] were observed below T_N and T^*, respectively. Recent epithermal neutron diffraction experiment directly evidenced that this material has the complex magnetic structure with the wave vector [1/4 1/4 1/2] below T_N [3]. Interestingly, this wave vector is the same in other rear earth hexaborides, such as CeB_6. However, there was a possibility that the magnetic structure of GdB_6 is incommensurate such as PrB_6 because of the resolution limit of the wave vector $\boldsymbol{Q}$ in the epithermal neutron diffraction experiment. Therefore we have performed resonant and non-resonant x-ray scattering on GdB_6 in order to get more information about the magnetic structure and lattice distortions.

Experimental Procedure

The sample used in the present study is the same single crystal used in the previous epithermal neutron diffraction experiment. The x-ray scattering experiments were performed on BL4C, BL16A2 and BL1B of the Photon Factory, KEK, Japan. The sample with the (0 0 1) surface was mounted in a closed-cycle refrigerator. The mosaic spread of the sample at 5.5 K was about 0.02° FWHM.

Results and Discussions

In the non-resonant x-ray experiment on BL4C and BL16A2 using the incident x-ray energy E = 6.86 keV below the Gd L_{III} absorption edge, we scanned in reciprocal space along the main symmetry directions. In addition to the superlattice reflections at [0 0 1/2] and [1/2 1/2 0], the new superlattice reflection at the wave vector [1/4 1/4 1/2], which is the same wave vector determined by the epithermal neutron diffraction, has been observed. This reflection has been also reported by McMorrow et al. [4]. The polarization analyses of the superlattice reflection at [1/4 1/4 1/2] were performed using a Cu analyzer. The analyses revealed that the superlattice reflection in the temperature region between T^* and T_N includes σ–π' component and its intensity depends on the azimuth angle, indicating that the reflection is due to magnetic x-ray scattering. On the other hand, interestingly, the superlattice reflection below T^* is σ–σ' scattering within experimental errors. This result indicates that the superlattice reflection at [1/4 1/4 1/2] is mainly due to a lattice distortion.

In the resonant x-ray experiment on BL4C, large resonance enhancements at [1/4 1/4 1/2] were observed near the Gd L_{III} absorption edge in the temperature region between T^* and T_N, as shown in Fig. 1. The ratio between the maximum intensity and the intensity for non-resonant scattering (E = 6.86 keV) is of the order of 100. The complex energy dependence below T^* may be due to the lattice distortion. The temperature dependence of the intensity at the (1/4 1/4 5/2) reflection in resonance at E = 7.243 keV is quantitatively consistent with the results of the epithermal neutron diffraction.

In the present study, we confirmed that the magnetic structure of GdB_6 is commensurate structure with the wave vector [1/4 1/4 1/2] by high $\boldsymbol{Q}$ resolution experiment. However, the puzzling problem that the wave vector of the lattice distortion is identical to that of the magnetic structure below T^* is open at present.

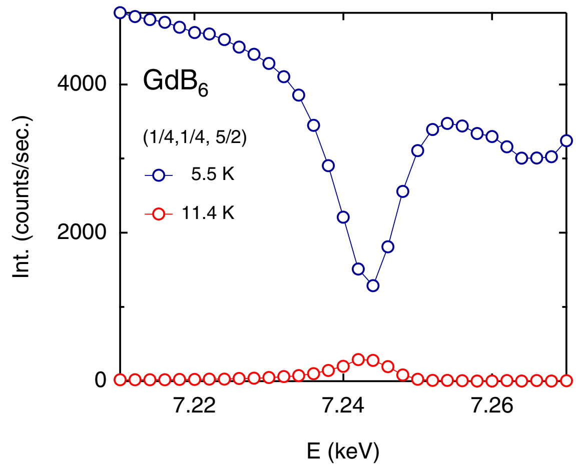

Figure 1 Incident energy dependence of the intensities of the (1/4 1/4 5/2) reflection at 5.5 K and 11.4 K.

References

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