4C, /2001G039

Resonant magnetic x-ray diffraction study of SmB_2C_2

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Introduction

The tetragonal LaB_2C_2 type compounds RB_2C_2 (R=rare earth) exhibit fairly complicated phase diagrams caused by competition between antiferroquadrupolar and antiferromagnetic interactions. SmB_2C_2 shows successive phase transitions at T_{N1}=51.9K and T_{N2}=35.6K [1]. Since the magnetic entropy released at the two transitions is about Rln2, these transitions are considered to be magnetic. However, Sm has rather high absorption cross section for neutrons, x-ray magnetic diffraction experiments are desired.

Experimental

Resonant x-ray diffraction experiments were carried out at beamline BL4C. The incident x-rays were monochromatized by a Si 111 double-crystal monochromator and were focused by a cylindrically bent mirror. The incident photon energy was tuned at the vicinity of Sm L_{III} absorption edge (E = 6.716 keV). A single crystal was mounted on the cold finger of a closed-cycle He refrigerator on a four-circle diffractometer.

Results

We first searched resonant magnetic diffraction peaks below T_{N2}. Energy spectra were measured at Q=(0,0,3/2), (1,0,1/2), (1,0,1) and (1.5,0.5,1) and a huge enhancement of the intensity was observed only at Q=(1,0,1). The resonance energy is 6.703 keV and is considerably lower than the observed main-edge energy 6.71 keV. Accordingly, this resonance is a quadrupole transition from $2p_{3/2}$ to 4f. We also performed a line scan from (1,0,1) to (1.5,0.5,1) at this resonance energy and found no peak. Therefore, the low-temperature phase of SmB_2C_2 is a commensurate antiferromagnet, which is described by the propagation vector (1,0,0)

We then moved on to a search of the order parameter in the intermediate phase. A line scan from (1,0,1) to (1.5,0.5,1) at the resonant energy was carried out at 40K, and a sharp peak was observed at Q=(1.13, 0.13,1). This peak shows clear enhancement in intensity at 6.703 keV as shown in Fig. 1. At Q=(0,0,3/2) and (1,0,1/2), no enhancement is observed again. Furthermore, at Q=(1,0,1), no additional intensity is observed compared with the paramagnetic phase. Therefore, it is considered that the propagation vector in the intermediate phase is only Q=(1.13,0.13,0), and hence it turned out that an incommensurate magnetic order is realized in the intermediate phase.

The integrated intensities of the peaks at Q=(1,0,1) and (1.13,0.13,1) are shown in Fig. 2 as a function of temperature. The 101 reflection appears only below 38K. The intensities above 38K is due to 2/λ. In contrast, the peak at Q=(1.13,0.13,1) is observed between 34.5K and 50K. This figure clearly shows an incommensurate-to-commensurate magnetic phase transition in SmB_2C_2.

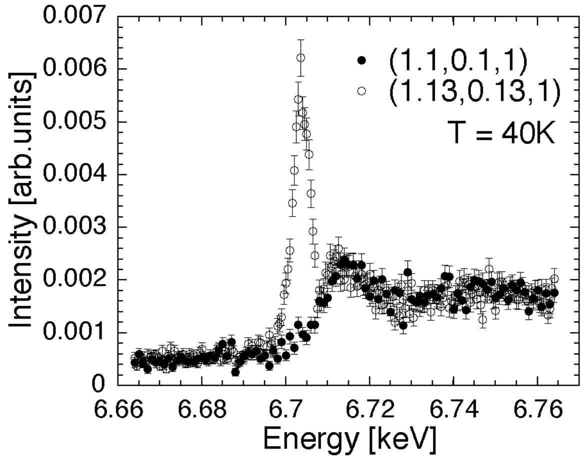

Fig. 1 Incident energy dependence of the magnetic reflection in intensity. Background due to fluorescence is estimated from data at Q=(1.1,0.1,1).

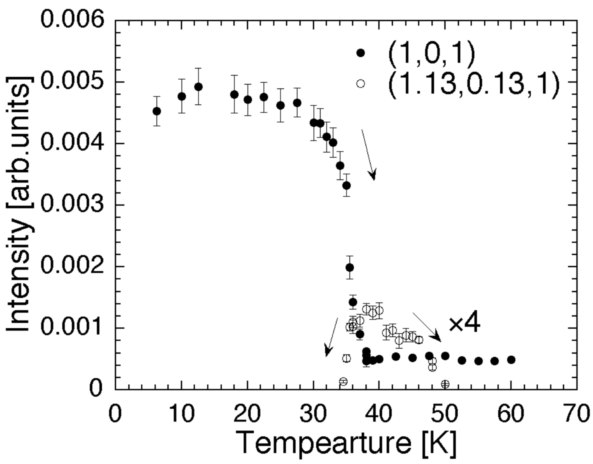

Fig. 2 Integrated intensities of the magnetic reflections as a function of temperature.

Reference

[1] K. Indoh et al., Physica B 312-313, 381 (2002).

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