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Appearance of short-ranged quadrupolar order in $Dy_xY_{1-x}B_2C_2$

Takeshi MATSUMURA*[1], Daisuke OKUYAMA[1], Hironori NAKAO[1], Youichi MURAKAMI[1]
Yusuke WAKABAYASHI[2], Hiroshi SAWA[2], Kazuma HIROTA[1]
Kentaro INDOH[3], Masato SAKATA[3], Hideya ONODERA[3]
[1]Department of Physics, Tohoku University, Sendai 980-8578, Japan
[2]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan
[3]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

Introduction

DyB_2C_2 is a typical compound which exhibits two phase transitions of antiferroquadrupolar (AFQ) order below TQ=25 K and antiferromagnetic (AFM) order below TN=15K. The resonant x-ray scattering have been successful to observe the AFQ order, for which neutron diffraction is not appropriate. The ordered state is described by the propagation vectors of (0 0 1/2), (1 0 1/2), (0 0 0) and (1 0 0). Among them (1 0 0) is magnetic which appears below T_N. The detailed examination of the superlattice reflections on energy, polarization, azimuthal angle, and temperature dependences revealed the feature of the AFQ order[1,2].

In the present experiment, we have diluted Dy concentration with nonmagnetic Y ions by 30%, and have investigated the change in the nature of the AFQ and AFM orderings.

Experimental Results

Energy dependence

Figure 1 shows the energy dependences of the typical superlattice reflections at the lowest temperature. Basically, the observed characters are the same as those in DyB_2C_2. For σ–π' channels of the (1 0 2) and (1 0 2.5) magnetic reflections, the interference effects between nonresonant and resonant scattrings are nicely observed. Various improvements of the beamline made it possible to reveal these detailed nature of the reflections than the previous experiments of Refs. [1] and [2].

Temperature dependence

Figure 2 shows the temperature dependences of the integrated intensities of typical reflections. The unit is transferred to the count rate at the peak tops. It should be noted that intensities are still observed apparently even above the transition temperatures of T_N=10 K and T_Q=13.5 K.

This feature may be attributed to the short ranged AFQ and AFM orders. The behavior above T_Q for the (0 0 2.5) reflection in σ–σ' channel, which reflects the AFQ order, seems to be almost the same with that of DyB_2C_2[2]. However, unfortunately, the critical behaviors of other reflections, especially that of the (1 0 2.5) nonresonant reflection which reflects the lattice distortion, have not been investigated in DyB_2C_2.

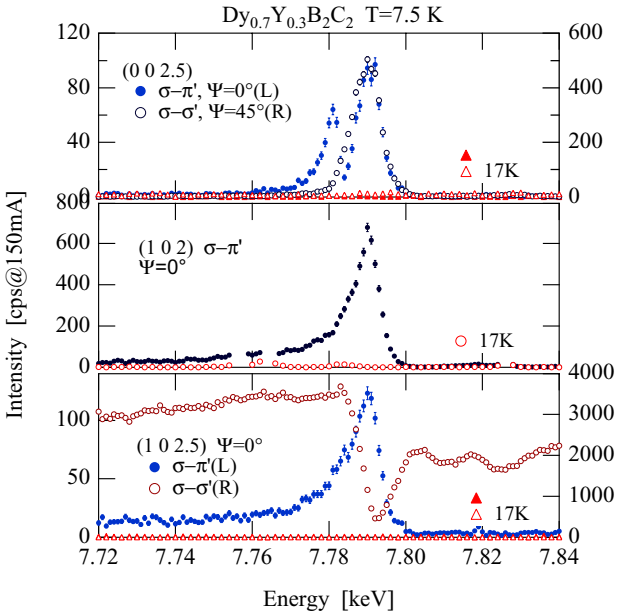

Fig. 1 Energy dependence of the superlattice reflections at the lowest temperature. Background at 17K is also shown.

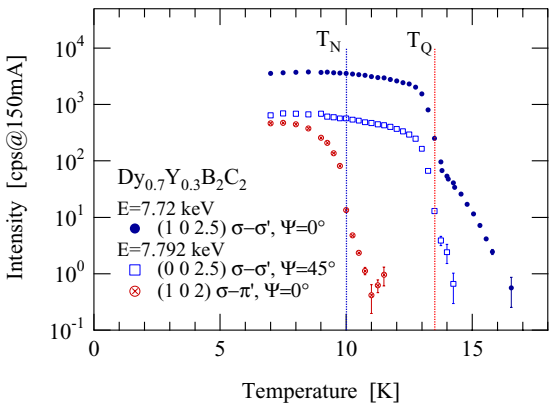

Fig. 2 Temperature dependences of the integrated intensities. T_N and T_Q are indicated by the vertical lines.

References

[1] K. Hirota et al., Phys. Rev. Lett. 84, 2706 (2000).
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* tmatsu@iiyo.phys.tohoku.ac.jp