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Cross-over of magnetic and quadrupolar order in $Dy_{0.8}Gd_{0.2}B_2C_2$

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Introduction

DyB_2C_2 undergoes antiferroquadrupolar(AFQ) order below T_Q=25 K and antiferromagnetic(AFM) order below T_N=15 K. Resonant x-ray scattering experiments successfully observed the superlattice reflections corresponding to the AFQ order, and the structure of the quadrupolar moments below T_Q was determined[1,2]. In the course of studies of the AFQ orders, an unusual phase called the phase IV, which appears when T_N crosses over T_Q, as observed in $Ce_xLa_{1-x}B_6$ and HoB_2C_2, has been attracting interests. Recently, Onodera has started to investigate the $Dy_{1-x}Gd_xB_2C_2$ system, where the Dy ions are substituted with Gd which has only spin moment, and has discovered the cross-over of T_N and T_Q[3].

However, the signature of T_N is so vague. Specific heat only shows a broad anomaly around 19 K, which they claims to be T_N, while at 17 K there appears a sharp anomaly which they attributes to the AFQ order. The purpose of this experiment is to clarify the anomaly at 19 K and identify the phase below 17 K.

Experimental Results

Energy dependence

Figure 1 shows the energy dependences of the superlattice reflections at the lowest temperature of 8.3 K. The same energy and polarization dependences as those for the AFQ+AFM phase in DyB2C2 is observed. Then, it is concluded that the phase below 17 K is the AFQ+AFM phase.

Temperature dependence

Figure 2 shows the temperature dependences of the integrated intensities of the superlattice reflections. It is noted that all of the reflections associated with the AFQ order appear below 17 K while the (1 0 2) reflection associated with the AFM order appears below 19 K. It is noteworthy that the broad anomaly at 19 K in the specific heat measurement is accompanied by such a clear emergence of the order parameter. Then, it is concluded that below T_N=19K the system orders antiferro-magnetically with k=<1 0 0> and below T_Q=17 K the AFQ order takes place.

Another interesting characteristic is the difference in the temperature dependences. Some reflections grow up with normal curvature with critical exponent β~0.33, while some grow up almost linearly with β more than 0.5.

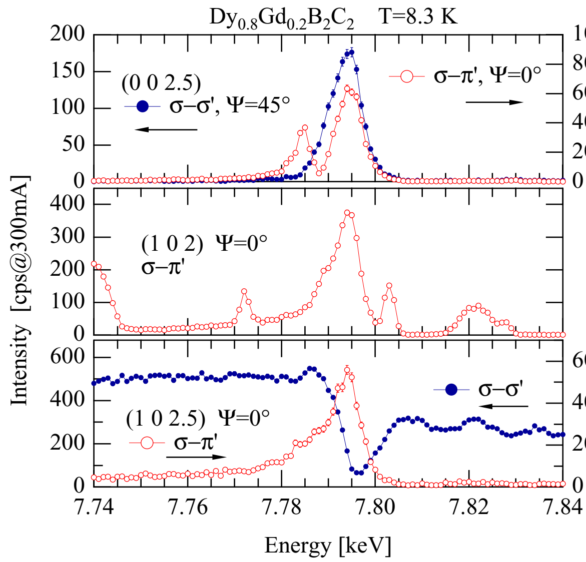

Fig. 1 The energy dependences of superlattice reflections.

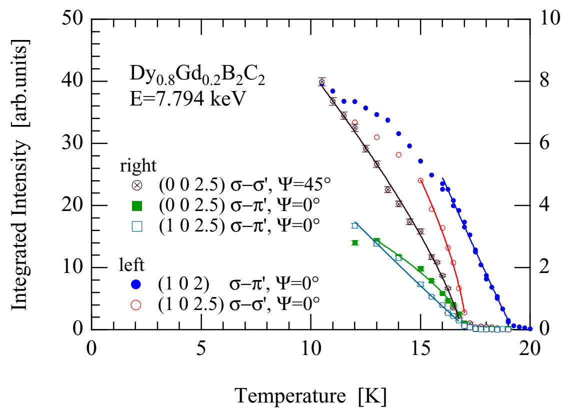

Fig. 2 Temperature dependences of the integrated intensities of the superlattice reflections. Lines are the fits to deduce the critical exponents.

References

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