1st order transition in $ErNi_2B_2C$

H. Kawano-Furukawa, Y. Ishida , S. Ohira-Kawamura, H. Yoshizawa[a] and H. Takeya[b]
Ochanomizu Univ., ISSP NSL Univ. of Tokyo[a] and NIMS[b]

$ErNi_2B_2C$ is the first material in which a microscopic coexistence of weak ferromagnetism (WFM) and superconductivity (SC) was directly confirmed by a neutron scattering measurements in zero field [1]. $ErNi_2B_2C$ transforms to a superconducting state at $T_c = 10.5$ K, a SDW state at $T_N = 6$K and a weak ferromagnetic state at $T_{WFM} =$ 2.3K. At early stage of the study, Zarestky *et. al.* [2] and Sinha *et. al.* [3] independently performed neutron diffraction measurements and both group independently observed that clear magnetic peaks develope below T_N at incommensurate wave vector $q \sim 0.553$a* and spins on Er atoms order transversely polarized planar sinusoidal structure. After these works, we performed unpolarized and polarized neutron diffraction measurements and succeeded in confirming microscopic coexistence between the WFM and the SC by showing an appearance of an interferance term below $\sim$ 2.3K at both (0 0 2) and (0 0 6) nuclear Bragg positions of the $ErNi_2B_2C$ crystal [1,4]. In those studies, however, we noticed that temperature dependence of the magnetic intensity shows a hysteresis behavior around 2.3K. To check an origin of this anomaly, we performed further neutron diffraction measuremtns.

In the present study, we used single crystals of $ErNi_2^{11}B_2C$ grown by a floating zone method. T_c of our un-annealed sample is determined to be $\sim$ 8.6 K which is same crystal with the one used in the previous experiment [1].

Figures show temperature dependence of neutron diffraction intensities at (a) (1 0 0) and (2) (0 0 1). These two points are equivalent Bragg positions for the WFM order parameter. But data show different temperature dependence around 2.3K. This result indicates a rotation of spins. To check this behavior in more detail we measured neutron diffraction profiles along (h 0 1) and (h 0 0) (not shown). With such date, we concluded that that the ferromagnetic order in $ErNi_2B_2C$ first develops with spins along the a-axis below 2.3K but it rotate along the b-axis at 1.8K through a first order transition.

[1] H. Kawano *et al.*, J. Phys. Chem. Solids **60**, 1053 (1999)

[2] J. Zarestky *et al.*, Phys. Rev. B **51**, R678 (1995).

[3] S.K. Sinha *et al.*, Phys. Rev. B **51**, R681 (1995).

[4] H. Kawano-Furukawa *et al.*, Phys. Rev. B **65**, 180508 (2002)

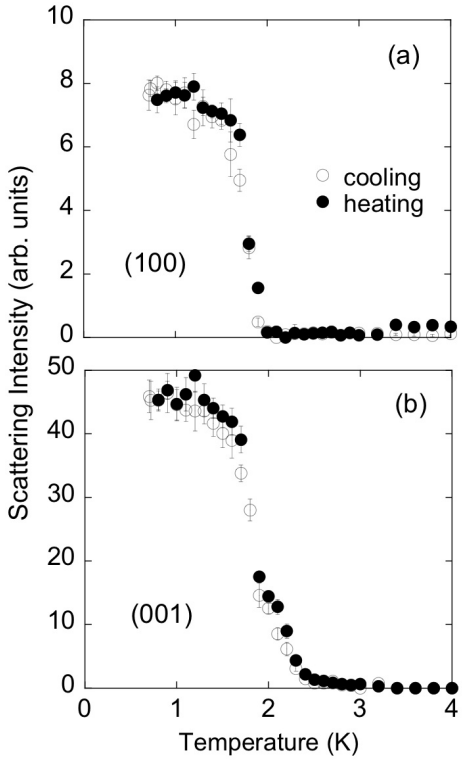

Fig. 1. Temperature dependence of Bragg intensities at (a) (1 0 0) and (b) (0 0 1).