Small Angle Neutron Scattering Studies of Spontaneous Vortex Phase in $ErNi_2B_2C$

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Background and purpose

It is microscopically confirmed that $ErNi_2B_2C$ exhibits the coexistence of weak ferromagnetism (WFM) and superconductivity below $T_{WFM} \sim 2.5\ K$ [1]. For a type II ferromagnetic superconductors, it is predicted that an internal magnetic field H_{int} mediated by the ferromagnetic moments may lead a spontaneous vortex phase if H_{int} satisfies a condition: $H_{c1} < H_{int} < H_{c2}$ [2].

$ErNi_2B_2C$ is one of possible candidates for the spontaneous vortex phase because the estimated H_{int} satisfies the above condition of the spontaneous vortex phase. In this study, SANS experiment was performed in order to examine the possibility of spontaneous vortex phase in $ErNi_2B_2C$.

Experimental method and results

The SANS experiment was performed at the Paul Scherrer Institute in Switzerland. The single crystals of $ErNi_2B_2C$ were prepared using floating zone method. The measurements were carried out at T=3 K (spin density wave phase) and T=0.1 K (week ferromagnetic phase).

At 0.1 K after the zero field cooled (ZFC) procedure, the external magnetic field H_{ext} as large as 2000 Oe was applied, and then it was reduced down to 0 Oe. Figure 1 shows the FLL (flux line lattice) diffraction pattern measured at H_{ext}=0 Oe and T= 0.1 K after this procedure. The effective field H_{eff} was calculated from the diffraction patterns obtained at each fields.

Figure 2 shows the field dependence of internal field H_{int} (= H_{eff} - H_{ext}). H_{int} is not zero at H_{ext} = 0 Oe and T = 0.1 K although H_{int} is zero at H_{ext} = 0 Oe and T = 3 K, which may suggest the realization of spontaneous vortex lattice. The internal field H_{int} increases at both 3 K and 0.1 K as the external field H_{ext} increases, showing that the magnetic moments at both SDW phase and WFM phase tend to align with the external magnetic field.

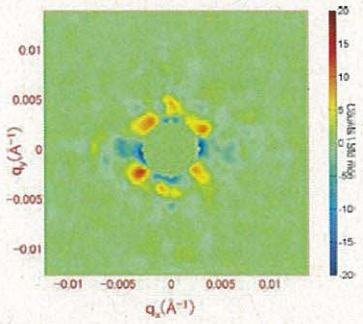

Figure 1: FLL diffraction pattern at H_{ext}=0 Oe, T=0.1K

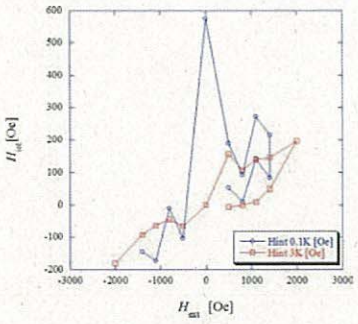

Figure 2: Field dependence of H_{int}

References

[1] H. Kawano, H. Takeya, H. Yoshizawa and K. Kadowaki, J. Phys. Chem. Solids. **60** (1999) 1053.

[2] M. Tachiki et. al., Solid State Commun. **34** (1980) 19.