Search for magnetic excitation in a heavy fermion superconductor $CeCoIn_5$

N. Aso, H. Miyano, H. Yoshizawa, T. Fujiwara[A], G. F. Chen[B], N. K. Sato[B]

ISSP, Univ. of Tokyo, Graduate School of Sci. and Engineering, Yamaguchi Univ.[A], Graduate School of Sci., Nagoya Univ.[B]

The interplay between magnetism and superconductivity (SC) is the interesting and important issue on condensed matter physics. A recently discovered series of $CeMIn_5$ (M = Rh, Co and Ir) has the highest SC transition temperature T_c = 2.3 K for heavy fermion materials. [1] It is believed that such a high T_c can be realized by strong antiferromagnetic (AFM) fluctuations. For example, $CeRhIn_5$ exhibits an incommensurate AFM ordering with the wave vector of τ= (0.5, 0.5, 0.297). [2] Very recently G.G. Chen et al. [3] reported that high-quality single crystalline $CeRhIn_5$ display the SC at $T_c \sim 90$ mK even under ambient pressure (P) and its P-T phase diagram is also drastically renewed. These findings indubitably indicate that the identical f electron plays both roles of SC and AFM. Therefore $CeRhIn_5$ is a very importance material for the investigations on the coexistence of SC and AFM. To elucidate the nature of both SC and AFM, it is very useful to perform inelastic neutron scattering which is a very powerful tool to directly observe the dynamical spin susceptibility of the system.

In this context, we first succeed in observing the low-energy magnetic excitations in $CeRhIn_5$. [4] Inelastic neutron scattering spectrum at constant energy of $\hbar\omega$ = 0.8 meV in the (h, h, l)-zone and T = 1.4 K clearly showed a strong intensity along the (0.5, 0.5, l) line, indicating that the low-energy magnetic excitation is a two-dimensional nature. Thus the main goal of our study is to detect the low-energy magnetic excitations in $CeCoIn_5$ and to determine its energy scale of the dynamical susceptibility $CeCoIn_5$, and to compare them between $CeRhIn_5$ and $CeCoIn_5$.

Single crystals of $CeCoIn_5$ were grown by In-flux method. Inelastic neutron scattering experiments were carried out at 4G (GPTAS) and C1-1 (HER) spectrometers in the research reactor JRR-3. (hhl)-zone was selected as the scattering plane. The crystals with the total mass of $\sim$ 0.5 gram were aligned with the total area of $\sim$ 300 mm^2 and were cooled down to T = 1.5 K.

We observed very weak low-energy excitations below 1.5 meV at Q = (0.5, 0.5, 2.3), (0.5, 0.5, 2.5) and (0.5, 0.5, 2.7). Unfortunately we can not identify whether these intensities are Q-dependent nor identify that this signal is of magnetic origin. The possible reasons are that the used crystals are not enough for the inelastic neutron scattering study and that the temperature of 1.5 K is not low enough for T_c = 2.3 K.

Note: After our work, we noticed that the group of Collin Broholm detected the low-energy magnetic excitations around the commensurate AFM wave vector τ = (0.5, 0.5, 0.5) in $CeCoIn_5$ with total mass of $\sim$ 5 gram. A sharp spin resonance ($\hbar\Gamma <$ 0.07 meV) at $\hbar\omega$ = 0.60 $\pm$ 0.03 meV develops in the SC state and disappears above T_c. [5]

References

[1] C. Petrovic *et al.*, *J. Phys.: Condens. Matter* **13**, L337 (2001).

[2] W. Bao *et al.*, *Phys. Rev.* **B 62**, R14621 (2000); *ibid* **63**, 219901(E) (2001); *ibid* **67**, 099903(E) (2003).

[3] G. F. Chen *et al.*, *Phys. Rev. Lett.* 97 (2006) 17005.

[4] N. Aso *et al.*, NSL-ISSP Activity Report **14** (2007) 227; *ibid* **15** (2008) in these repot.

[5] C. Stock *et el.*, arXiv:0712.0172v1.