Low-energy magnetic excations in a heavy fermion superconducting antiferromagnet $CeRhIn_5$

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The interplay between magnetism and superconductivity is the interesting and important issue on condensed matter physics. Although it has been considered to be exlusive over quantum critical point, it is now widely accepted that both superconductivity (SC) and antiferromagnetism (AFM) coexist in the vicinity of quantum critical point in the systems of the pressure-induced superconductor $CePd_2Si_2$, $CeIn_3$, and $CeRhIn_5$ [1, 2] and so on after a lot of energetic investigations. Since it, however, is very difficult to establish the coexistence of both two phases under pressure because of the inhomogeneity of the pressure, there is open to argument if the coexistance is intrinsic. Very recently G.G. Chen et al. from Nagoya Univ. [3] reported that high-quality single crystalline $CeRhIn_5$ display the SC at $T_{SC} \sim 90$ mK even under ambient pressure and its pressure-temperature phase diagram is 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 coexistance of SC and AFM. To elucidate the coexistance mechanism 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. The main goal of our study is to determine the wave vector dependence and its enegy scale of the dynamical susceptibility $CeRhIn_5$, and to find out the connection between SC and the dynamical susceptibility.

On the other hand, since the Rh and In nuclei are strong neutron absorbers, there has been little information on low-energy magnetic excitations by inelastic neutron scattering studies. In this work, we prepared a lot of large single crystals of $CeRhIn_5$ and succeeded in detecting the dynamical spin susceptibility at the ISSP/HER spectrometer in the reserach reactor JRR-3/JAEA. Figure 1 shows inelastic neutron scatteirng spectrum at the antiferromagnetic ordering wave vector Q = (0.5,0.5,2.7) at temperatures of T = 1.4 K (below T_N), 10 K and 40 K (above T_N). Accurate temperature-dependence of the dynamical susceptibility have shown that, surprisingly, the low-energy magnetic excitations gradually start developing below 40 K (10 times larger than T_N). We are now continuing to study the overview of the low-energy part of its dynamical susceptibility of both $CeRhIn_5$.

References

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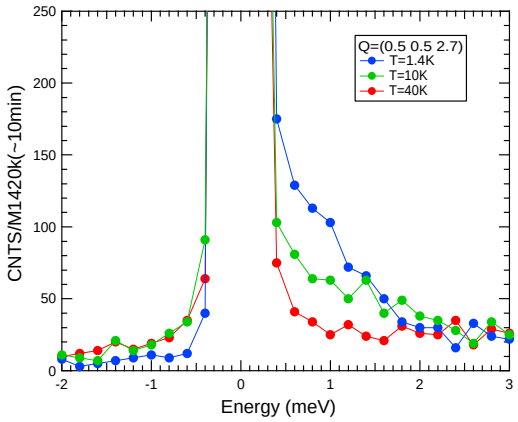

Fig. 1. Inelastic neutron scatteirng spectrum at the antiferromagnetic ordering wave vector Q = (0.5,0.5,2.7) as a function of temperature.