Evolution of commensurate magnetic state in the heavy-fermion superconductor $CeRh_{0.6}Co_{0.4}In_5$

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In recent years, there has been growing interest in the physical property near the quantum critical point (QCP) in the heavy-fermion systems. The heavy-fermion compound $CeRhIn_5$ orders in an incommensurate antiferromagnetic (AF) phase with the modulation of $q_h = (1/2, 1/2, 0.297)$ [1]. It is revealed in the Co-doped alloys $CeRh_{1-x}Co_xIn_5$ [2] that the AF phase is suppressed with increasing x, and then disappears at $x_c \sim 0.7$. At the same time, the superconducting phase appears between $x = 0.4$ and $x = 1$. The evolution of superconducting state around x_c implies that these two states are strongly coupled with each other. To investigate the relation between these two phases, we have performed the elastic neutron scattering experiments for $CeRh_{0.6}Co_{0.4}In_5$ [3].

Single crystals of $CeRh_{0.6}Co_{0.4}In_5$ were grown by the In-flux method. The samples were shaped into bar (typical size: $\sim 3\ mm^2 \times 20$ mm) in order to minimize the effects of the neutron absorption caused by the Rh and In ions contained in the samples. The unpolarized and polarized elastic neutron scattering experiments were performed using triple-axis spectrometers GP-TAS and PONTA located at the JRR-3M research reactor of JAEA, respectively. The measurements were performed in the (hhl) scattering plane for both the experiments.

Figure 1 shows the neutron scattering pattern obtained by the $(1/2, 1/2, 1+\zeta)$ $(0 \leq \zeta \leq 1)$ scan at 1.4 K, using unpolarized neutron beam. We have found that three nonequivalent Bragg peaks, other than nuclear ones expected from the tetragonal structure, develop at low temperatures. The wave vector characterizing these peaks are estimated to be $q_h = (1/2, 1/2, 0.306)$, $q_1 = (1/2, 1/2, 0.402)$, and $q_c = (1/2, 1/2, 1/2)$. The polarized neutron scattering experiments indicate that all these peaks originate from the magnetic scatterings. The appearance of the Bragg peaks for q_h is attributed to the incommensurate AF order, since pure $CeRhIn_5$ also shows this type of order. On the other hand, the development of the Bragg peaks relevant to the modulation of q_c and q_1 indicates that new AF orders evolve with intermediate Co concentration. We are now planning to perform further neutron scattering experiments for entire x range to elucidate the nature of these AF phases.

References

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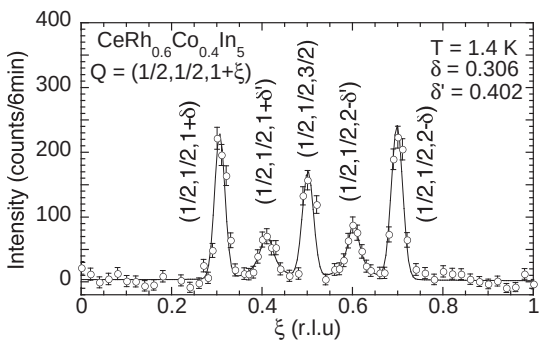

Fig. 1. The antiferromagnetic Bragg-peak profiles at 1.4 K.