A phase transition between the itinerant and the localized f-electron states in the heavy fermion antiferromagnet Ce(Ru0.9Rh0.1)2(Si1-yGey)2

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In the heavy fermion systems, f-electrons are hybridized with conduction electrons (cf-hybridization), and hence, localized spins and heavy quasi-particles coexist[1]. This duality of f-electrons can lead an alternation between an itinerant and a localized magnetic orders by changing the strength of the cf-hybridization in the heavy fermion systems[2,3]. The former is a spontaneous magnetic polarization of the heavy quasi-particle band (quasi-particle band regime), whereas the latter is formed by the localized spin via the RKKY-interaction (RKKY-regime).

In the course of searching for such an alternation of schemes of the magnetic order, we have studied the magnetic properties of the pseudo-binary alloy system Ce(Ru0.9Rh0.1)2(Si1-yGey)2. The base material Ce(Ru0.9Rh0.1)2Si2 is known as an archetypal heavy fermion compound which shows a spin density wave (SDW) transition[4]. By substituting Ge for Si, we effectively apply negative pressure to the SDW phase through the lattice expansion, and the magnetic order can be shifted to the antiferromagnetic order formed by the localized f-spins(LAF)[3,5]. Recently, we found a 1st order phase transition between the SDW and the LAF phases in the Ce(Ru0.9Rh0.1)2(Si1-yGey)2 system by the substitution of Ge for Si[6].

In 2006, we have performed neutron scattering experiments under hydrostatic pressure for Ce(Ru0.9Rh0.1)2(Si1-yGey)2 with y = 0.30, showing the LAF transition at ambient pressure, using the 4G spectrometer installed at the JRR-3M. Figure 1 shows temperature dependences of integrated intensities of magnetic reflections with (a) q1 = (0.344,0,0) and (b) q3 = (0,0,0.358). The former and the latter reflections, the q1- and the q3-reflections, correspond to the LAF and the SDW phases respectively. The figure shows that only the q1-reflection is found at ambient pressure. On the other hand, the q1-reflection disappears and the q3-reflection appears at high pressure region, $P > 0.5$GPa. In the intermediate pressure region, $0.30\text{GPa} < P < 0.5\text{GPa}$, both the magnetic reflections are found, which indicates the coexistence of the SDW and the LAF phases. This experimental results under hydrostatic pressure strongly suggest the pressure induced 1st order phase transition between the SDW and the LAF phases, reproducing very nicely the chemical pressure effects for the Ce(Ru0.9Rh0.1)2(Si1-yGey)2 system.

[1] K. Miyake and Y. Kuramoto, Physica B 171 (1991) 20.
[2] S. Quezel, P. Burlet, J. L. Jacoud, L. P. Regnault, J. Rossat-Mignod, P. Lejay, J. Flouquet, J. Magn. Magn. Mater. 76-77 (1988) 403.
[3] K. Watanabe, Y. Uwatoko, Y. Tabata, H. Kadowaki, C. Kanadani, T. Taniguchi, S. Kawarazaki, J. Phys. Soc. Jpn. 72 (2003) 1751.
[4] S. Kawarazaki, M. Sato, H. Kadowaki, Y. Yamamoto, Y. Miyako, J. Phys. Soc. Jpn. 66 (1997) 2473.
[5] Y. Tabata, K. Watanabe, T. Taniguchi, C. Kanadani, S. Kawarazaki, Physica B 329-333 (2003) 508.
[6] Y. Tabata et al., to be published.

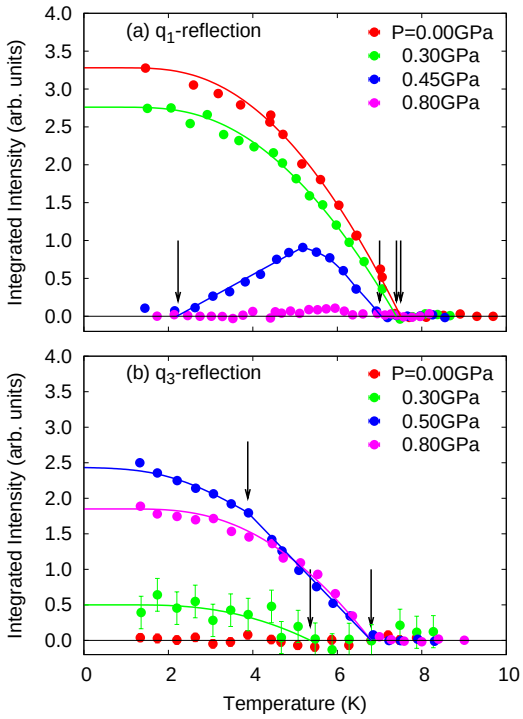

Fig. 1. Temperature dependences of the integrated intensities of magnetic reflections with (a) q1 = (0.344,0,0) and (b) q3 = (0,0,0.358) under hydrostatic pressure.