(P2-10)

Substitution effect on the multipolar transitions in $Pr(Fe_xRu_{1-x})_4P_{12}$

Y. Aoki, Y.Motomura, D.Kawana, Y.Yonezawa, D.Kikuchi, K.Kuwahara, H.Sato

Graduate School of Science, Tokyo Metropolitan University, Hachioji, 192-0397

Among the highly-correlated electron states in Pr-based filled skutterudites, one of the important issues is to understand the order parameters of the anomalous nonmagnetic phase A (presumably of multipolar origin) below $T_A = 6.5$ K in $PrFe_4P_{12}$ and the insulating phase I below $T_{MI} = 63$ K in $PrRu_4P_{12}$. Here, we report a study on $Pr(Fe_xRu_{1-x})_4P_{12}$ single crystals, focusing on the stability of the ordered phases against the mutual doping.

Figure 1 shows the renormalized electrical resistivity $\rho(T)/\rho(T = 290\ \mathrm{K})$ and the x dependences of T_{MI} and T_A deduced from the $\rho(T)$ data. As evident from the figure, it has been found that both of the transition temperatures are significantly sensitive against the doping. This fact may suggest that the Fermi-surface-nesting instability plays an essential role for both of the orderings.

In the non-ordered state, $PrFe_4P_{12}$ shows an obvious $-\ln T$ behavior, indicative of Kondo-like scatterings of 4f electrons. This behavior is significantly suppressed by the Ru doping for the Fe site and no such behavior is visible in $PrRu_4P_{12}$. According to band structure calculations (Harima et al.), the Fe $3d$ bands in $PrFe_4P_{12}$ appear on the Fermi level, while the Ru $4d$ bands in $PrRu_4P_{12}$ are much deeper and the only one conduction band crossing the Fermi energy consists mainly of P $3p$ molecular orbitals. Therefore, these observations may suggest that $4f - 3d$ mixing process plays an essential role for the Kondo-like scatterings.

Another factor that needs to be considered is the different CEF level scheme between the two compounds. $PrFe_4P_{12}$ has a low-lying magnetic triplet state, which lies far above the singlet ground state in $PrRu_4P_{12}$. That CEF level scheme in $PrFe_4P_{12}$ may be desirable for the Kondo effect and the heavy fermion behavior.

The disappearance of the phase A by the Ru doping is closely correlated with that of the Kondo-like scatterings. This fact may point to a scenario that the nonmagnetic degrees of freedom relevant for the phase A (presumably multipolar moments) are the same with those for the Kondo-like scattering. This view is discussed combining with specific heat and other data.

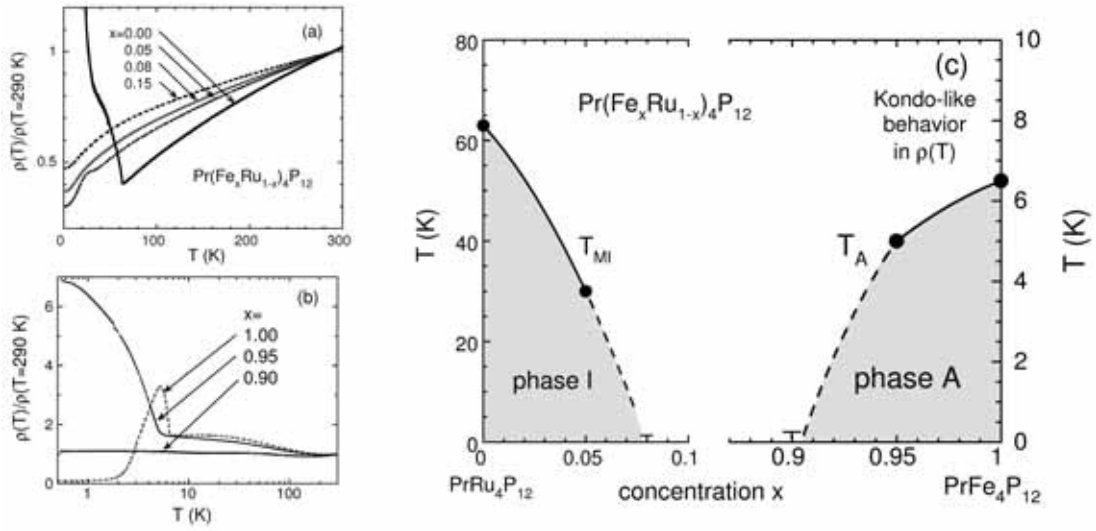

Figure 1: $\rho(T)$ data and the deduced phase diagram of $Pr(Fe_xRu_{1-x})_4P_{12}$.