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Specific Heat and Electrical Resistivity of Filled Skutterudite $GdRu_4P_{12}$ in a Magnetic Field

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We report the results of specific heat and electrical resistivity $\rho(T)$ in a magnetic field on filled skutterudite $GdRu_4P_{12}$. $GdRu_4P_{12}$ shows an antiferromagnetic transition at T_N= 22 K [1]. $\rho(T)$ indicates a metallic behavior below room temperature. Interestingly, $\rho(T)$ shows a broad minimum around 30 K and a sharp upturn at T_N. The sharp upturn at T_N suggests a formation of superzone gap in the unique Fermi surface with the nestng vector **q**=(1,0,0). The systematic research on $Ln Ru_4P_{12}$ with various $4f$ electron state is necessary in order to reveal the role of $4f$ electron in the metal-insulator transition of $PrRu_4P_{12}$ and $SmRu_4P_{12}$.

Figure 1(a) shows the $\rho(T)$ of $GdRu_4P_{12}$ in various magnetic fields. Applying magnetic field, the sharp upturn at T_N becomes small and shifts to lower temperature. Finally, the upturn disappears in 7 T. The broad minimun around 30 K disappears in 2 T. From the analysis of $\rho(T)$ data, we found that the zero field-resistivity due to the c-f exchange scattering from the Gd^{3+} $4f$ energy levels increases below ∼60 K. Inset shows the magnetic phase diagram. The magnetic phase diagram is consistent with the previous result of magnetization process at 4.2K and 10 K [1]. The large negative magnetoresistance (∼ -70 %) observed at 2.2 K is qualitatively explained by a collapse of superzone gap (Fig.1(b)).

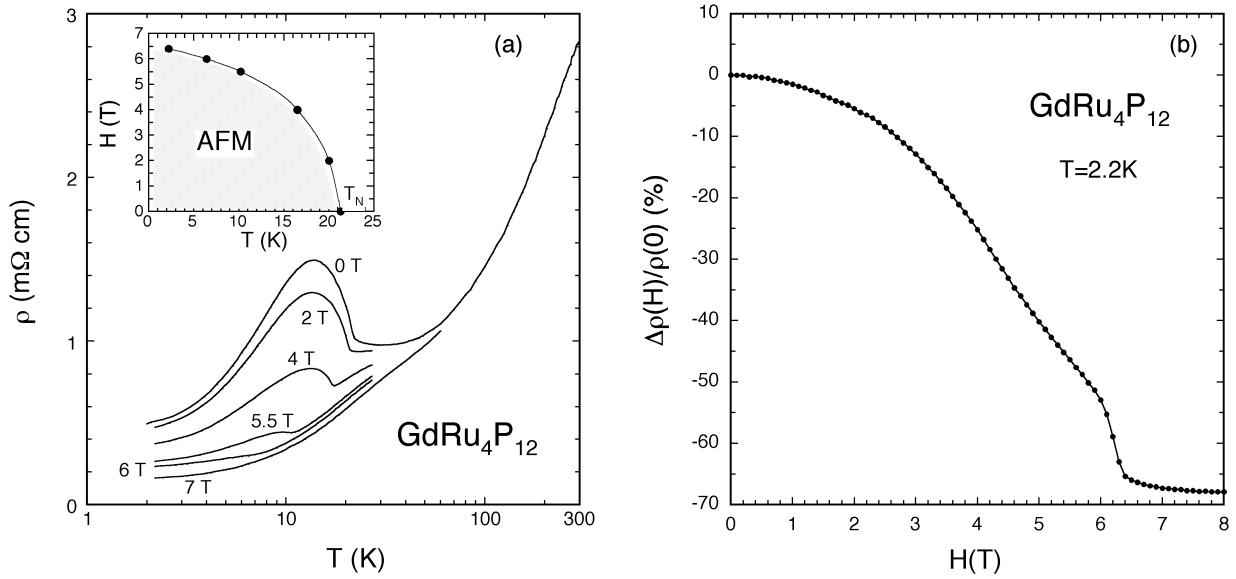

Figure 1: (a) Eelectrical resistivity of $GdRu_4P_{12}$ in various magnetic fields. Inset shows the magnetic phase diagram. (b) Magnetoresistance of $GdRu_4P_{12}$ at 2.2 K.

[1] C. Sekine, T. Uchiumi, I. Shirotani, K. Matsuhira, T. Sakakibara, T. Goto and T. Yagi: Phys. Rev. B **62** (2000) 11581.