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Non-fermi liquid-like behavior in a heavy lanthanide compound $YbFe_4P_{12}$

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Recently, a new filled skutterudite with heavy lanthanide element, $YbFe_4P_{12}$, has been successfully synthesized. The lattice constant,[1)] susceptibility,[1)] and specific heat[2)] measurements indicate that $YbFe_4P_{12}$ is in an intermediate-valence state between Yb^{2+} and Yb^{3+}. However, the electric resistivity exhibits the minimum near 45 K, followed by an increase at low temperatures.[1)] The specific heat C has two distinct anomalies: a λ-type peak at $\simeq$0.7 K and a Schottky-type peak near 30 K.[2)] The latter is attributed to the crystal-field splitting effect, whereas the origin of the former is not yet clarified. In addition, the electronic specific heat coefficient $\gamma = C/T$ below $\sim$10 K exhibits a divergent increase,[2)] yielding a rough estimate of $\gamma(T{=}0) \sim 0.3$ J/mol$\cdot$K^2. To elucidate the electronic and magnetic states of $YbFe_4P_{12}$ at a microscopic level, we have carried out ^{31}P nuclear magnetic resonance (NMR) measurements.

Figure 1 shows the dependence of the nuclear spin-lattice relaxation rate $1/T_1T$ on the temperature. Below $\sim$50 K, $1/T_1T$ strongly depends on both temperature T and applied magnetic field H, and follows the power-law relation $1/T_1T = AT^{-\alpha}$ over one decade. As shown in Fig. 2, the power $\alpha \sim 0.1$ at 7.0 T increases with decreasing H and takes the maximum value of $\simeq 0.7$ at 0.2 T, which is close to the value 3/4 expected for the non-Fermi liquid (NFL) state associated with antiferromagnetic spin fluctuations. We suggest that $YbFe_4P_{12}$ is an interesting material in which the NFL-like behavior occurs below a rather high temperature of $\sim$10 K, and a magnetic field of about 0.2 T is sufficient to bring it to its quantum critical point.

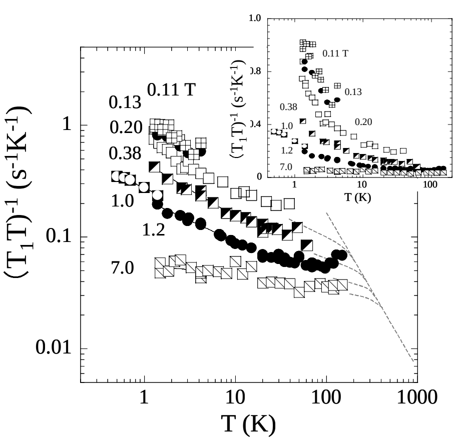

Figure 1: Temperature dependence of the ^{31}P spin-lattice relaxation rate $1/T_1T$ in $YbFe_4P_{12}$. The virtual dotted lines are drawn in the figure as a guide to the eye. The $1/T_1T$ data are replotted in the inset on a semi-log scale.

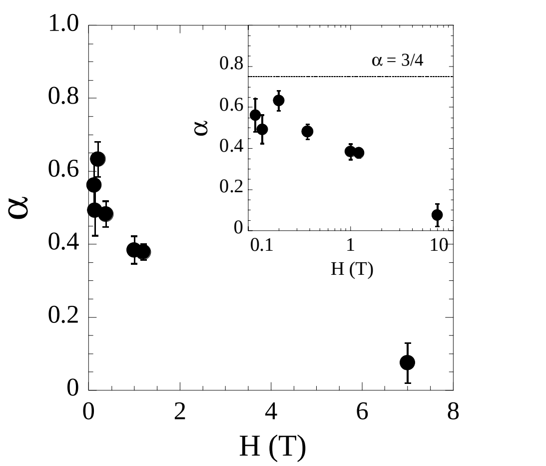

Figure 2: Field dependence of power α in the relation $1/T_1T = AT^{-\alpha}$ for ^{31}P in $YbFe_4P_{12}$. The data are replotted in the inset on a semi-log scale.

1) I. Shirotani *et al.* : J. Phys.: Condens Matter **17**(2005) 4383.

2) M. Wakeshima *et al.* :*Proceedings of Joint Workshop on NQP-skutterudites and NPM in multi-approach* (Hachioji, Tokyo, 2005) PB28.