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NMR study on Sm-based Filled-Skutterudite Compounds

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We report the results of the ^{31}P-NMR study for $SmFe_4P_{12}$ which shows heavy fermion behavior with a large electronic specific heat coefficient γ of 370 mJ/mol K^2 and ferromagnetic ordering below $T_C \sim 1.6$ K [1]. In Fig.1, we summarized the temperature dependence of the spin lattice relaxation rate $1/T_1$ measured at various magnetic fields. This result clearly shows a change in the temperature dependence of $1/T_1$ around 30 K, *i.e.* with decreasing temperature, from weak temperature dependence of T_1 to $T_1T \sim$ constant behavior. Such a phenomenon is interpreted as the crossover from a well-localized electrons state at high temperature to a Fermi liquid one due to a formation of heavy electrons, which is in good agreement with the sharp decrease in the resistivity below around 40 K and the large γ value in $SmFe_4P_{12}$ [1].

Besides, what should be noticed here is anomalous behavior below ~ 8 K, *i.e.* $1/T_1$ is again weakly dependent on temperature and is strongly affected by magnetic field. This unusual temperature dependence below ~ 8 K is probably ascribed to remaining degrees of freedom in localized electronic spins with low energy spectral weight for the following reasons; (1) Once the degrees of freedom are removed from the electronic spins at T_C, $1/T_1$ rapidly decreases from the nearly constant value. (2) The nearly constant behavior of T_1 is easily suppressed by a few tesla of magnetic field, indicating existence of localized-electrons and not of itinerant-electrons. The anomaly around 8 K is also observed in the temperature dependence of the specific heat [2]. It is interesting to mention that a similar behavior of $1/T_1$ was reported on $PrFe_4P_{12}$ [3,4] in which the occurrence of an antiferro-quadruple ordering was suggested [4].

[1] N. Takeda and M. Ishikawa, J. Phys.: Condens. Matter **15** (2003) L229.
[2] K. Matsuhira *et al.*, (unpublished); C/T shows a broad peak at ~ 8 K.
[3] K. Ishida *et al.*, (unpublished); J. Kikuchi *et al.*, (unpublished).
[4] M. Kohgi *et al.*, J. Phys. Soc. Jpn. **72**, 1002 (2003).

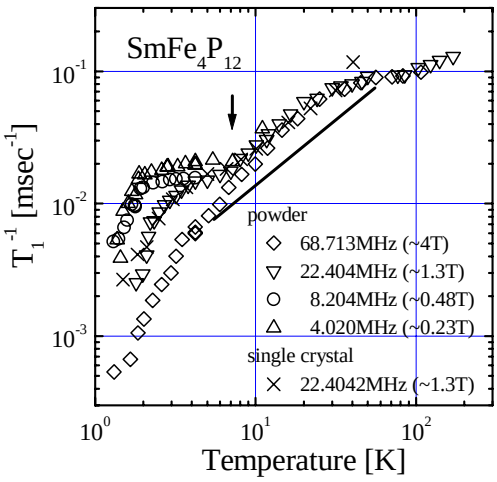

Figure 1: The temperature dependence of $1/T_1$ measured at various magnetic fields.