(28a6)

Antiferro-quadrupole order and non-Fermi-liquid behavior in $PrFe_4P_{12}$: ^{31}P NMR

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We report on the results of ^{31}P NMR in $PrFe_4P_{12}$ which exhibits antiferro-quadrupole (AFQ) order below 6.5 K at zero field. From the analysis of the symmetry of dipolar and quadrupolar moments in the T_h crystal field, and using the NMR and neutron-diffraction data presently available [1], we propose that the AFQ order parameter (OP) is of Γ_{23} type. It is also suggested that the OP should be composed of both the independent quadrupoles O_2^0 and O_2^0 in order to give qualitative account for the nonmonotonous, site-dependent field variations of the NMR line splitting (Fig. 1). On the dynamics, the nuclear spin-lattice relaxation rate $1/T_1$ exhibits remarkable anisotropy in the high-field heavy-fermion phase. For the field $\mathbf{H}$ applied along $\langle 111 \rangle$, we observed enhanced, almost temperature-independent $1/T_1$ at low temperatures. The non-Fermi-liquid behavior of $1/T_1$ may be related with either the quadrupolar Kondo effect [2] arising from near degeneracy of the T_h crystal-field levels for $\mathbf{H} \| \langle 111 \rangle$, or existence of some ordered phase at lower temperatures found recently by the magnetization measurement [3].

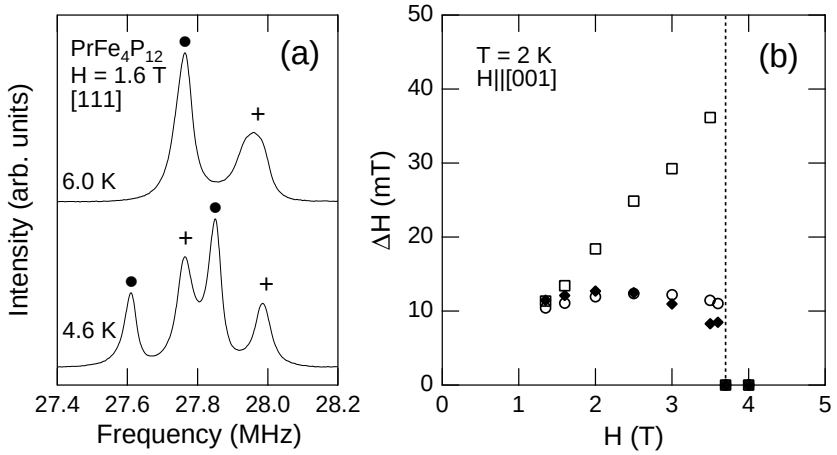

Figure 1: (a) ^{31}P NMR spectra in $PrFe_4P_{12}$ with the field along [111] above and below the transition temperature. (b) Field dependence of the line splitting at 2 K with the field along [001]. The different symbols correspond to the three inequivalent P sites in magnetic fields above the transition temperature.

[1] L. Hao *et al.*, Acta Phys. Polonica **34** (2003) 1113; K. Iwasa, unpublished.
[2] D. L. Cox, Phys. Rev. Lett. **59** (1987) 1240.
[3] T. Tayama, unpublished (28b1).