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Hyperfine Interactions and Spin Fluctuations in $\text{NpFe}_4\text{P}_{12}$: ^{31}P -NMR Study

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^{31}P -NMR measurements have been performed on a single crystal of the neptunium-based filled skutterudite $\text{NpFe}_4\text{P}_{12}$. The compound undergoes a ferromagnetic phase transition at $T_C = 23$ K with a large and negative magnetoresistance decaying in a relatively wide temperature range below $4T_C$ [1]. From the field-orientation dependence of ^{31}P -NMR line splitting, the angular dependence of the transferred hyperfine interactions between Np $5f$ spin moments and ^{31}P nuclei have been obtained. The anisotropic nature of the transferred hyperfine interactions lead us to estimate the local spin density at P $3p$ orbitals. It is shown that a fraction of Np $5f$ spin moment is transferred mostly into P $3p$ orbital extending toward the inside of a P-cage. The weak hybridization effect between Np $5f$ and P $3p$ orbital is indicative of the localized character of Np $5f$ electrons. We have also measured the field and temperature dependences of the nuclear spin-lattice relaxation rate ($1/T_1$) in several magnetic fields between 18.5 and 78.0 kOe. The $1/T_1$ data reveals the strong suppression of the low-energy spin fluctuations by the applied magnetic fields below 100 K. This finding demonstrates that the large and negative magnetoresistance observed in the same temperature range comes from the reduction of the magnetic scattering from the Np $5f$ spin moments. We will also discuss a low temperature anomaly associated with the reorientation of the Np $5f$ spin moments in the ferromagnetically ordered state [2].

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