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^{31}P -NMR study in uranium-based filled skutterudite compound $\text{UFe}_4\text{P}_{12}$

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$\text{UFe}_4\text{P}_{12}$ is the first reported uranium based filled skutterudite compound containing 5f electrons. Ferromagnetic ordering with a Curie temperature $T_C = 3.15\text{K}$ was reported on the basis of magnetization measurements. On the other hand, the electrical resistance shows a semiconductive T -dependence, that is, increases nearly 7 orders of magnitude as T is lowered from 300 K to 4.2 K. In order to clarify the role of 5f electrons in the Uranium filled skutterudite compound, we have performed the ^{31}P -NMR measurements using a single crystal.

Figure 1 shows the field-angle dependence of ^{31}P -NMR spectrum obtained at 50 K in an external field of 2.4 T. The NMR line splits into several peaks, and these peaks change position with sample rotation. The angular dependence of the peak position, corresponding to the angular dependence of the hyperfine (HF) field at the P nuclei, is shown in the upper panel of Fig. 2. We have obtained a series of six curves merging into four, three, and then two at the $\langle 110 \rangle$, $\langle 001 \rangle$, and $\langle 111 \rangle$ directions, respectively. The angle-dependent NMR line splitting is of purely magnetic origin, since the ^{31}P nuclei ($I = 1/2$) have no electric quadrupole moment. The lower panel of Fig. 2 shows the angular dependence of the dipolar field from the U moments calculated for twelve P sites in a unit cell. A series of six curves with a θ dependence similar to the experiment have been obtained. The agreement seen between calculated and experimental behavior confirms the full filling of U atoms as well as the absence of large magnetic moments on the Fe sites. Quantitatively, however, the present point-dipolar calculations are clearly rather smaller than the total anisotropic HF fields observed at the P sites, giving only about one-third of the magnitude of the experimental values. This suggests that another HF mechanism, i.e., the hybridization of the U spin moment into p-orbitals on the P sites, exists in the same order to the direct dipolar mechanism.

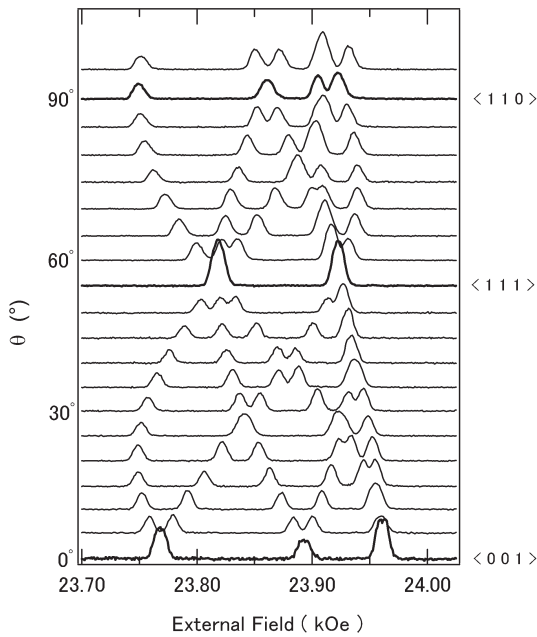


Figure 1

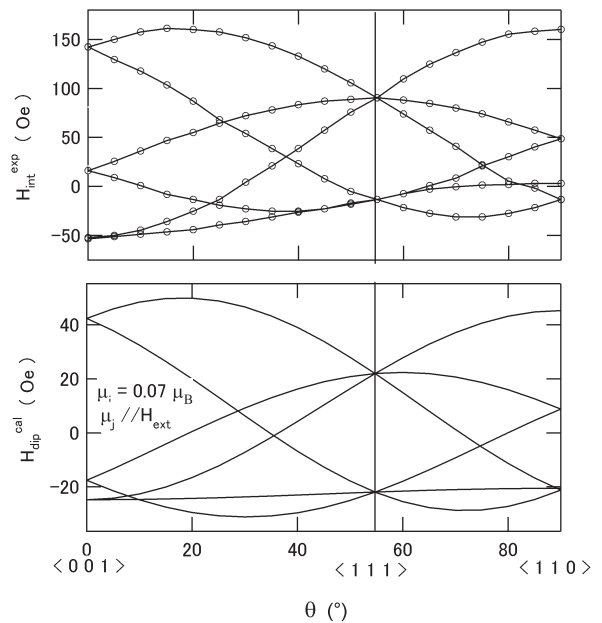


Figure 2