Lattice distortions measured in actinide ferromagnets PuP, NpFe2 and NpNi2

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Lattice distortions measured in actinide ferromagnets PuP, $NpFe_2$ and $NpNi_2$ (*)

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Résumé. — Les mesures de rayons X à basses températures indiquent que : (1) la phase cubique de PuP se transforme en une phase tétragonale en dessous de $T_C = 125$ K qui se manifeste par un élargissement des pics, (2) $NpFe_2$ montre une variation de l'angle du rhomboèdre de 60 à 60,53° en dessous de $T_C \sim 500$ K, et (3) pour $NpNi_2$ l'angle du rhomboèdre varie de 0,19° (± 0,02°) en dessous de $T_C = 32$ K.

Abstract. — X-ray low-temperature measurements indicate that : (1) cubic PuP distorts to tetragonal below $T_C = 125$ K with accompanying line broadening, (2) $NpFe_2$ exhibits a rhombohedral angle distortion from 60 to 60.53° below $T_C \sim 500$ K, and (3) in $NpNi_2$ the rhombohedral angle changes 0.19° (± 0.02°) below $T_C = 32$ K.

Actinide U and Np ferromagnets have been shown [1] to exhibit a large distortion from cubic symmetry below T_C, with all previous examples exhibiting a rhombohedral symmetry compatible with the ⟨ 111 ⟩ easy axes of magnetization found in these compounds. We report here the results of X-ray experiments at low temperature to examine the symmetry of PuP ($T_C = 125$ K), $NpFe_2$ ($T_C \sim 500$ K), and $NpNi_2$ ($T_C = 32$ K).

In PuP a ⟨ 100 ⟩ easy axis was found with neutron measurements [2] and, as expected, we find a tetragonal distortion such that

$$(c - a)/a = -(31 \pm 1)\ 10^{-4}$$

at 5 K. The variation of the lattice parameters and the strain are shown as functions of temperature in figures 1 and 2, respectively. Below T_C the diffraction peaks also broaden, presumably a consequence of strain induced by the magnetoelastic interactions (see Fig. 3).

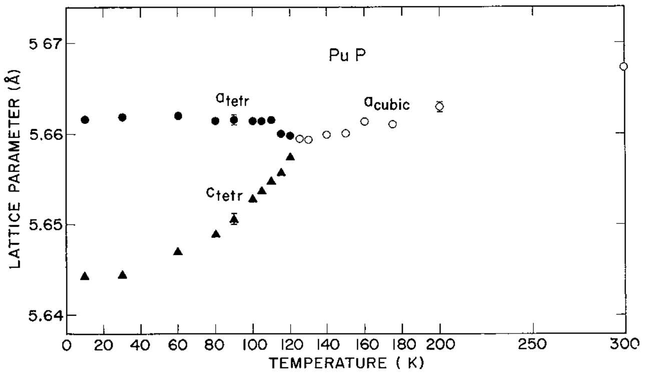

Fig. 1. — Variation of the lattice parameters as a function of temperature for PuP.

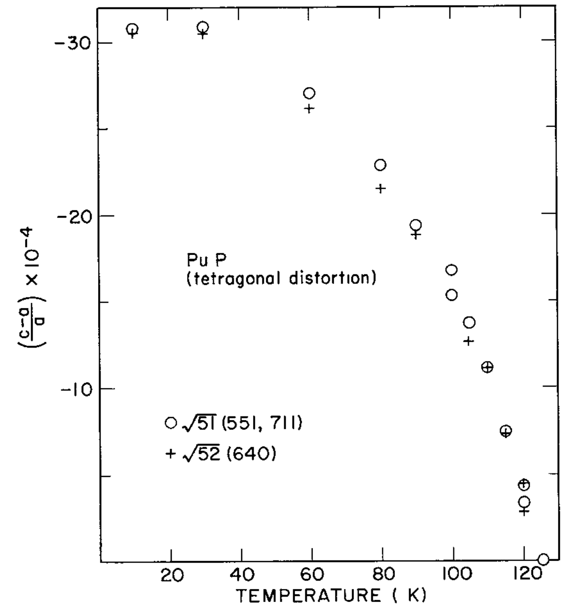

Fig. 2. — Tetragonal distortion for PuP as a function of temperature.

In $NpFe_2$ neutron experiments [3] determined a ⟨ 111 ⟩ easy axis and we find a rhombohedral distortion such that the rhombohedral angle changes from 60° to 60.53°. An alternative description of the rhombohedral distortion is to define a length c as a distance along the unique trigonal axis and a as a distance in the plane perpendicular to c such that $c/a = 1.00$ in the cubic phase. This definition is especially useful when comparing the magnitude of trigonal and tetragonal distortions. In this case the strain in $NpFe_2$ is $-(120 \pm 5)\ 10^{-4}$, which is the largest found in any actinide compound.

In $NpNi_2$ the quality of the powder patterns is rather poor, but we estimate the change in the

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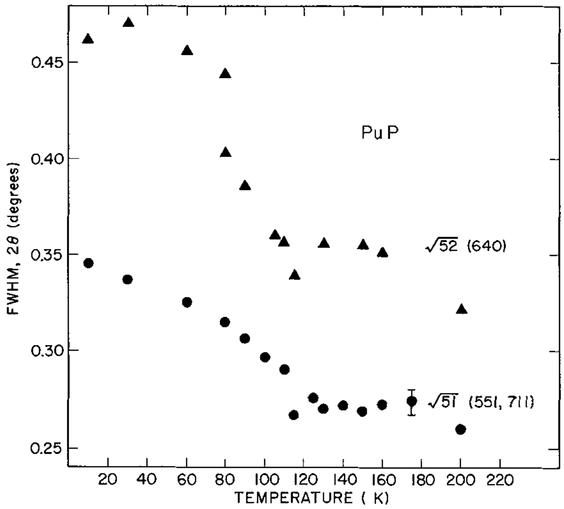

Fig. 3. — Diffraction peak broadening observed in selected reflections from PuP as a function of temperature.

rhombohedral angle to be $0.19° \pm 0.02°$ from the broadening of the lines below T_C. The absolute value of the strain is then $(43 \pm 5)\ 10^{-4}$. Our results are compatible with the theory that all actinide ferromagnets exhibiting localized 5f moments reduce their symmetry below T_C as a consequence of strong magnetoelastic interactions. PuP is the first system to be found with a tetragonal distortion, and $NpFe_2$ has the largest rhombohedral distortion found so far.

The behaviour of the ferromagnetic compounds is in contrast to the actinide antiferromagnets, in which the distortions are either small or negligible [1, 4]. This difference between the ferro- and antiferromagnets is not understood.

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