Magnetoelasticity of $Lu_2Fe_{16.5}Ru_{0.5}$

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R_2Fe_{17} (R is a rare earth) are compounds with very strong magneto-volume coupling and often exhibit Invar-like properties such as anomalous and anisotropic spontaneous magnetostriction and negative thermal expansion in a wide temperature range [1]. For Lu_2Fe_{17} with the smallest non-magnetic *R*, the competition of positive and negative exchange interactions between the Fe atoms at various crystallographic positions [2] of the hexagonal (Th_2Ni_{17} type) crystal structure results in the transformation of the low-temperature ferromagnetic (F) phase to the antiferromagnetic phase at the Curie temperature T_C = 130 K (Fig. 1). The non-collinear antiferromagnetism extends to the Néel temperature of T_N = 274 K. The application of external pressure and hydrogen charging act in the opposite way. While pressure suppresses ferromagnetism in Lu_2Fe_{17}, hydrogenation (can be considered as a positive pressure) completely removes the AF phase, and the compound $Lu_2Fe_{17}H$ becomes ferromagnetic [3]. Small substitution of Ru for Fe in Lu_2Fe_{17} leads to stabilization of the AF state down to the lowest temperatures. The Néel temperature of $Lu_2Fe_{16.5}Ru_{0.5}$ is 208 K (Fig. 1) [4].

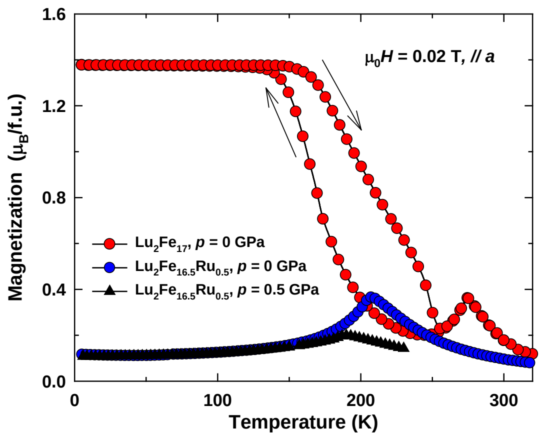

Fig. 1. Temperature dependence of magnetization *M*(*T*) of $Lu_2Fe_{16.5}Ru_{0.5}$ measured in the field 0.02 T under 0 and 0.5 GPa pressures. The *M*(*T*) of the parent Lu_2Fe_{17} under ambient pressure is shown for comparison.

The interplay of Ru substitution for Fe and hydrostatic pressure and their combined effects on the magnetoelasticity of $Lu_2Fe_{16.5}Ru_{0.5}$ were studied by means of powder neutron diffraction under hydrostatic pressure of up to 0.5 GPa and by magnetostriction measurements. Neutron diffraction data were collected on the diffractometer D1B (λ = 2.529 Å). The data analysis done using the FULLPROF program showed that $Lu_2Fe_{16.5}Ru_{0.5}$ has a helimagnetic antiferromagnetic structure. The propagation vector of the helix varies from 0.236*c** directly below T_N down to 0.219*c** at 2 K [4]. External pressure pushes the Néel transition towards the lower temperature. The T_N is ~190 K under the pressure of 0.5 GPa (Fig 1).

Magnetostriction of $Lu_2Fe_{16.5}Ru_{0.5}$ was measured by two independent methods. As the highly sensitive and accurate method, the capacitor dilatometer was employed for the measurement of the single-crystalline sample. The X-ray dilatometry, on the other hand has a much lower sensitivity and accuracy but is a direct method of determination of the interatomic distances changes. Furthermore, possible field-induced structure changes can be observed by means of X-ray diffraction. The atomic coordinates deduced from the powder neutron diffraction experiment were used for the refinement of the obtained X-ray diffraction patterns.

The magnetostrictive strains along the *a*- and *c*-axis and the volume effect at 5 T in $Lu_2Fe_{16.5}Ru_{0.5}$ are λ_a = 0.5*10^{-3}, λ_c = 1.0*10^{-3}, ω = 2.1*10^{-3}, respectively. The lattice *a* parameter remains nearly unchanged as the temperature decreases while the *c* parameter increases noticeably. The spontaneous volume magnetostrcition reaches the value of ω_s ~ 6*10^{-3}. The applied pressure compensates for the unit cell expansion at low temperatures and the AF interactions remain strong in $Lu_2Fe_{16.5}Ru_{0.5}$.

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