MOMENT COLLAPSE IN $U_xLa_{1-x}S$

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The pseudo-binary system $U_xLa_{1-x}S$, in which the NaCl structure is maintained throughout, shows quite unusual magnetic behaviour. Bulk magnetic [1] and neutron diffraction [2] studies revealed:
(1) The change of lattice constant is smooth and linear.
(2) The effective U moment is practically independent of x at ~2.25 μ_B, while the paramagnetic Curie temperature decreases linearly from 184 K (x = 1) to 52 K (x = 0.08). The change in sign occurs at x = 0.3.
(3) The Curie temperature first decreases linearly from 177 K (x = 1) to ~100 K for x = 0.6. In this temperature range the ordered moment seen by neutrons changes little ($\mu_{ord} \approx 1.5\,\mu_B$). Below x = 0.6, magnetic Bragg reflections could no longer be detected. The ordered moment must have collapsed to $\mu_{ord} \leq 0.4\,\mu_B$, which was the sensitivity limit. Extrapolation of high field (9 T) magnetization to zero field yields moments around 0.3–0.5 μ_B below the region of collapse, but this procedure is considered unreliable due to domain effects.
To clarify the situation we have performed μSR measurements on single crystals with x = 1, 0.8, 0.55, 0.4, 0.15 and 0 between 300 K and 0.1 K at the πM3 beamline. From previous μSR studies on related UX compounds with the NaCl structure, the muon is known to be stationary (up to 300 K) at its stopping position located in the center of a cube formed by two U and two X ions. At this position the local field B_μ cancels for a simple AFM structure. In a FM like US only the contact field will be present. Results of the present work are:
LaS: Relaxation in ZF is given by a static Gaussian Kubo-Toyabe function arising from the nuclear dipoles on ^{139}La. Full decoupling can be achieved in LF = 10 G.
US: The precession frequency and the muon spin relaxation rate in TF rise sharply on approaching T_C, as expected when moving towards a second order magnetic transition. The TF signal amplitude breaks down at T_C as a consequence of the appearance of spontaneous magnetization. In ZF a spontaneous spin precession pattern is seen below T_C. The frequency at 100 K is $\nu_\mu = 63.4$ MHz (B_μ = 4.7 kG).
$U_{0.8}La_{0.2}S$: The TF results for this compound are similar to those of US except for the shift in T_C, but spontaneous spin precession could no longer be seen in ZF.
$U_{0.55}La_{0.45}S$: According to the neutron data this compound already exhibits moment collapse, yet the TF-μSR parameters clearly show the presence of a magnetic transition at 110 K. The frequency shift near T_C is greatly reduced, while for x = 0.8 practically no change had been observed in this respect.
$U_{0.4}La_{0.6}S$: Peaking of the relaxation rate λ and of the precession frequency ν in applied field together with a loss of signal strength A_0 show that a magnetic transition still takes place at 60 K. The peak frequency shift is further reduced.
$U_{0.15}La_{0.85}S$: TF measurements indicate a magnetic transition at around 0.45 K. The signal amplitude does not break down, however. The likely reason is the formation of an AFM state (no spontaneous bulk magnetization) as suggested by the negative Θ_p. The maximal frequency shift is even further reduced.

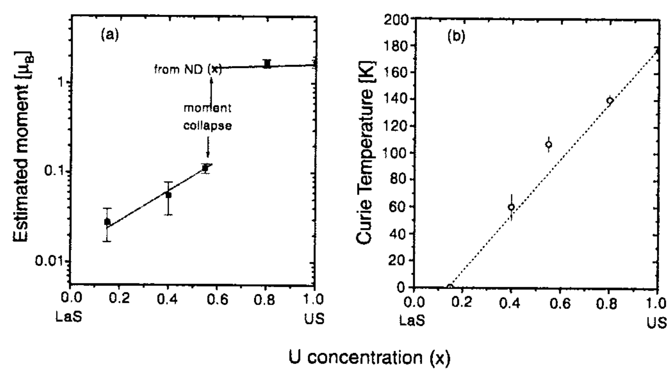

Figure 1: Temperature dependencies of the U moment and the transition temperatures for $U_xLa_{1-x}S$.

Due to the absence of spontaneous spin precession in the pseudo-binaries $U_xLa_{1-x}S$ we estimated the magnitude of the U moment from the maximum of the frequency shift at T_C. We find that the collapse of moment between x = 0.6 and x = 0.55 does not lead to vanishing moments, but they do become quite small (see Fig. 1). Furthermore, we observe magnetic transitions in all compounds which vary roughly linearly with temperature, meaning that the known high temperature result just continues. A theoretical study [4] predicts the moment collapse combined with the absence of magnetic order. The latter result is not verified.

REFERENCES

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