Title

Specific Heat of La{sub 1.875-x}Nd{sub x}Sr{sub 0.125}CuO{sub 4}: Magnetic and Structural Transitions

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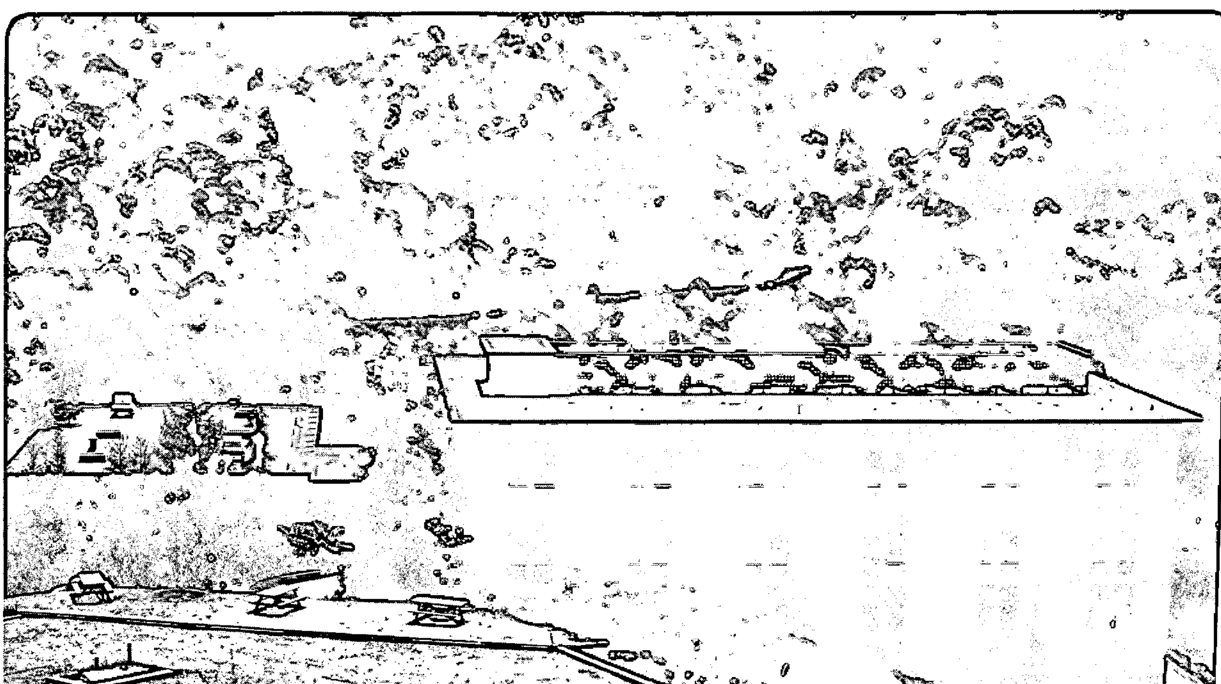

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MAGNETIC AND STRUCTURAL TRANSITIONS

by

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Specific Heat of $La_{1.875-x}Nd_xSr_{0.125}CuO_4$: Magnetic and Structural Transitions

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Near 70K $(La,Ba)_2CuO_4$ undergoes a structural transition from orthorhombic to tetragonal symmetry (LTO→LTT). Partial substitution of La by Nd produces an additional transition that has been observed in structural studies. The specific heats of $La_{1.475}Nd_{0.4}Sr_{0.125}CuO_4$ and $La_{1.275}Nd_{0.6}Sr_{0.125}CuO_4$ samples exhibit anomalies near 75K, which are associated with these structural transitions, and additional smaller anomalies near 30K, which may be associated with a magnetic transition detected by μSR.

The exploration of the relationship between structure and superconductivity in doped La_2CuO_4 began with the discovery of a structural phase transition below 100K, from orthorhombic (LTO) to tetragonal (LTT), by Axe et al.[1] in $La_{2-x}Ba_xCuO_4$ (LBCO). The LTT and LTO phases coexist in a ratio that depends on x and temperature. At x=0.125, where the LTT phase predominates, the Meissner fraction of LBCO is a minimum.[2] Although structural studies suggested that $La_{2-x}Sr_xCuO_4$ (LSCO) remains orthorhombic at low temperature, Specific-heat measurements[3] have given evidence for the occurrence of a transition similar to the LTO→LTT transition in $(La,Sr)_2CuO_4$ as well. At x=0.125 both LSCO and LBCO show a local minimum[2] in the superconducting transition temperature. The phase diagram of $La_{1.88-x}Nd_xSr_{0.12}CuO_4$ (LNSCO) shows the appearance of a second phase transition below 100K. On cooling, for doping levels in the range $0.2 \le x \le 0.6$, the structure transforms from LTO to a second orthorhombic phase (Pccn) to LTT.[4] These transitions correspond to small reorientations of the CuO octahedra.

Specific-heat data for LNSCO, plotted in Fig. 1, show a complex anomaly between 60 and 80K for x=0.4, as expected from the structural phase diagram. However, the shape of the anomaly at 80K for the x=0.6 data is more consistent with a single phase transition. Figure 2 shows the anomalies after subtraction of a smooth background represented by the solid curves in Fig. 1. The entropies associated with the anomalies are 357 mJ/K.mole and 171 mJ/K.mole for x=0.4 and 0.6, respectively. Because the entropy for x=0.6 is only about one half that for x=0.4, it seems that the LTO→Pccn transition has not occurred. The anomalies are not altered in a magnetic field of 7T.

Another anomaly, not associated with the structural phase transitions, appears near 30K in both samples. Its appearance is correlated with the detection by μSR of a magnetic anomaly near this temperature in LNSCO.[5] The data for H=0 and 7T are plotted in Fig. 3 as C/T^2 vs T to make the anomalies more apparent.

Fig. 4 is a plot of C vs log T below 20K. The Schottky-like anomalies are due to ordering of the Nd^{3+} electronic magnetic moments. The application of a 7T field shifts them to a higher temperature.

Specific-heat measurements[6] have been reported previously for $La_{1.85-x}Nd_xSr_{0.15}CuO_4$ with Nd in the range $0.12 \leq x \leq 0.7$. Anomalies were observed close to the LTO→LTT transition with the magnitude of the anomalies decreasing with decreasing x.

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1. J.D. Axe et al., Phys. Rev. Lett. **62**, 2751 (1989).
2. M.K. Crawford et al., Science **250**, 1390 (1990).
3. D.A. Wright et al., Physica C **185-189**, 1387 (1991).
4. M.K. Crawford et al., Phys. Rev. B **44**, 7749 (1991).
5. Y. Uemura, unpublished.
6. B. Büchner et al., Physica C**185-189**, 903 (1991).

FIGURE CAPTIONS

1. C/T vs T for LNSCO. The x=0.6 data have been displaced by 30 mJ/K^2.mole.
2. $\Delta C/T$ vs T near the LTO→LTT transition.
3. Possible magnetic anomalies near 30K.
4. Plot of C vs T showing the ordering of the Nd^{3+} electronic moments at low temperature.

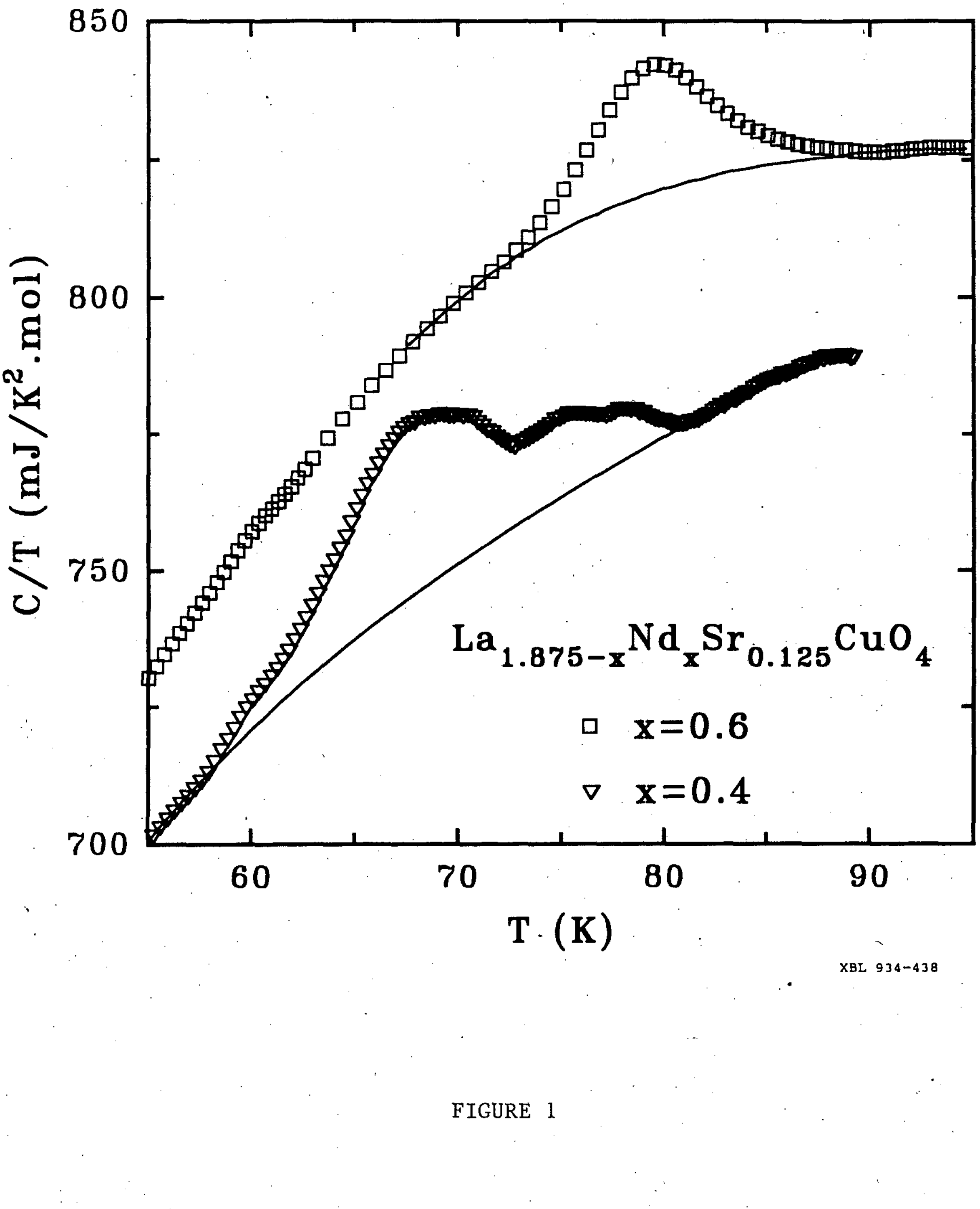
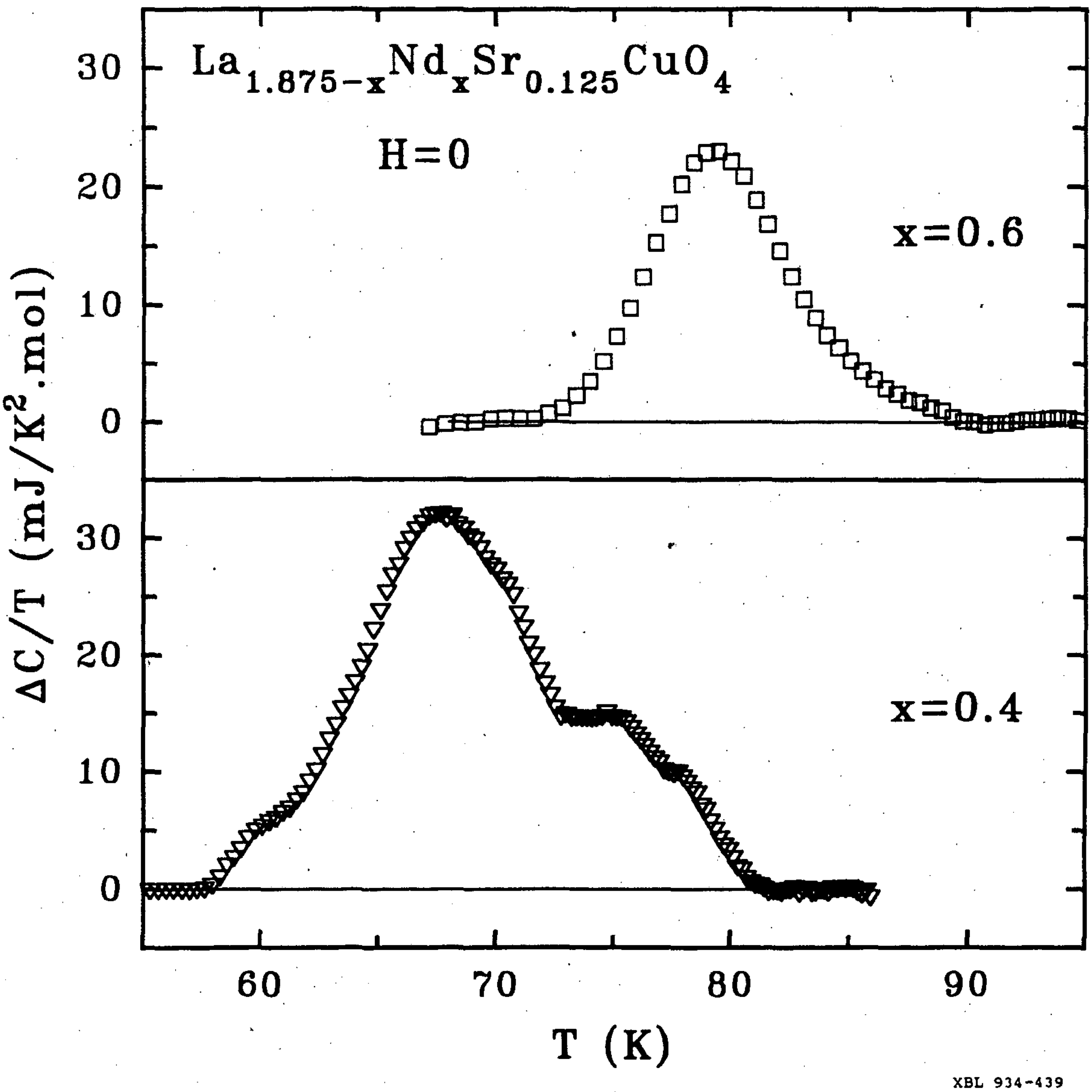

850
800
750
700
60
70
80
90
C/T (mJ/K².mol)
T (K)
La1.875-xNdxSr0.125CuO4
x=0.6
x=0.4
XBL 934-438

FIGURE 1



$La_{1.875-x}Nd_xSr_{0.125}CuO_4$
H=0
x=0.6
x=0.4
30
20
10
0
30
20
10
0
60
70
80
90
ΔC/T (mJ/K^2.mol)
T (K)
XBL 934-439

FIGURE 2

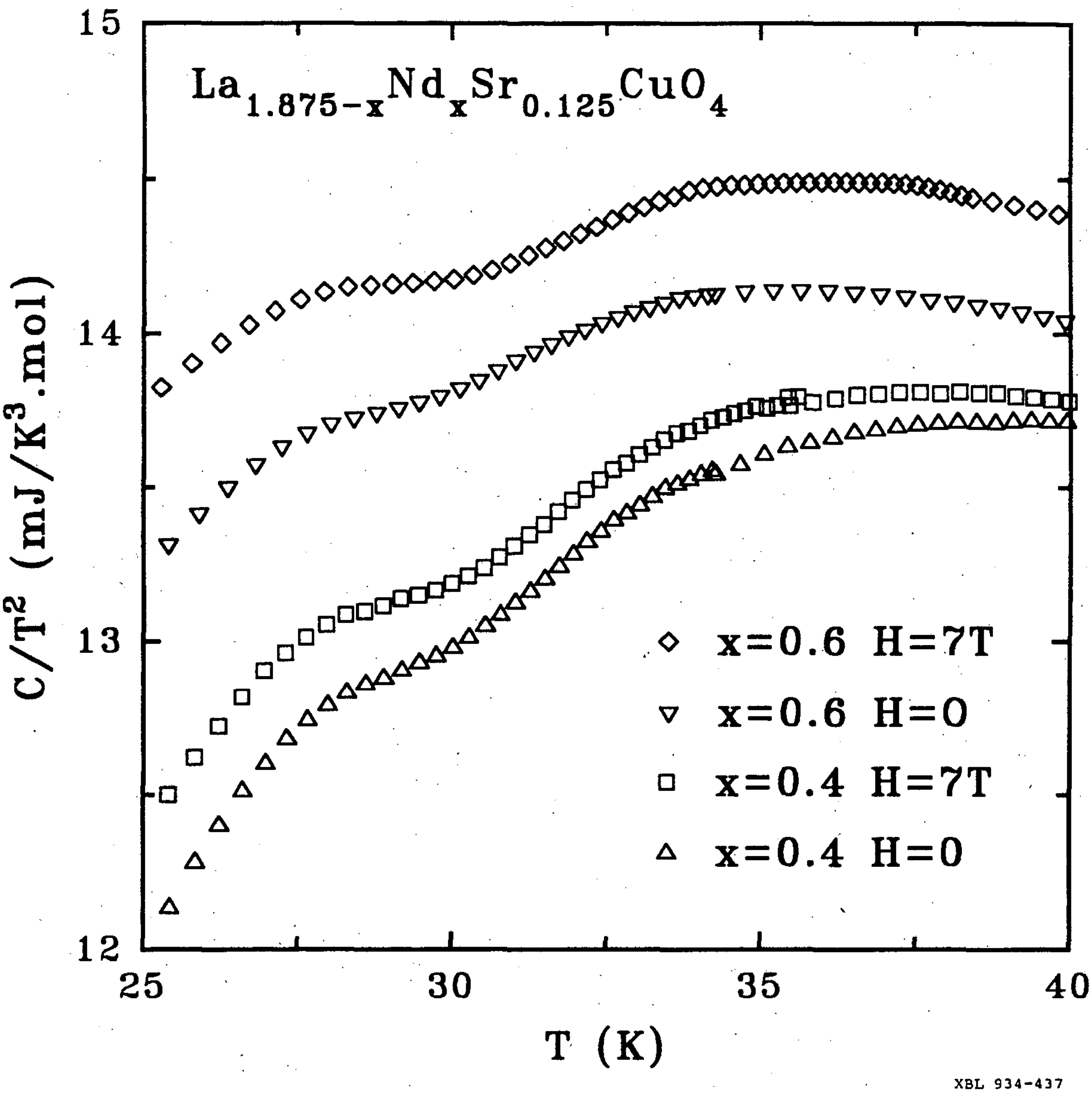

La1.875-xNdxSr0.125CuO4
C/T² (mJ/K³.mol)
T (K)
15
14
13
12
25
30
35
40
x=0.6 H=7T
x=0.6 H=0
x=0.4 H=7T
x=0.4 H=0
XBL 934-437

FIGURE 3

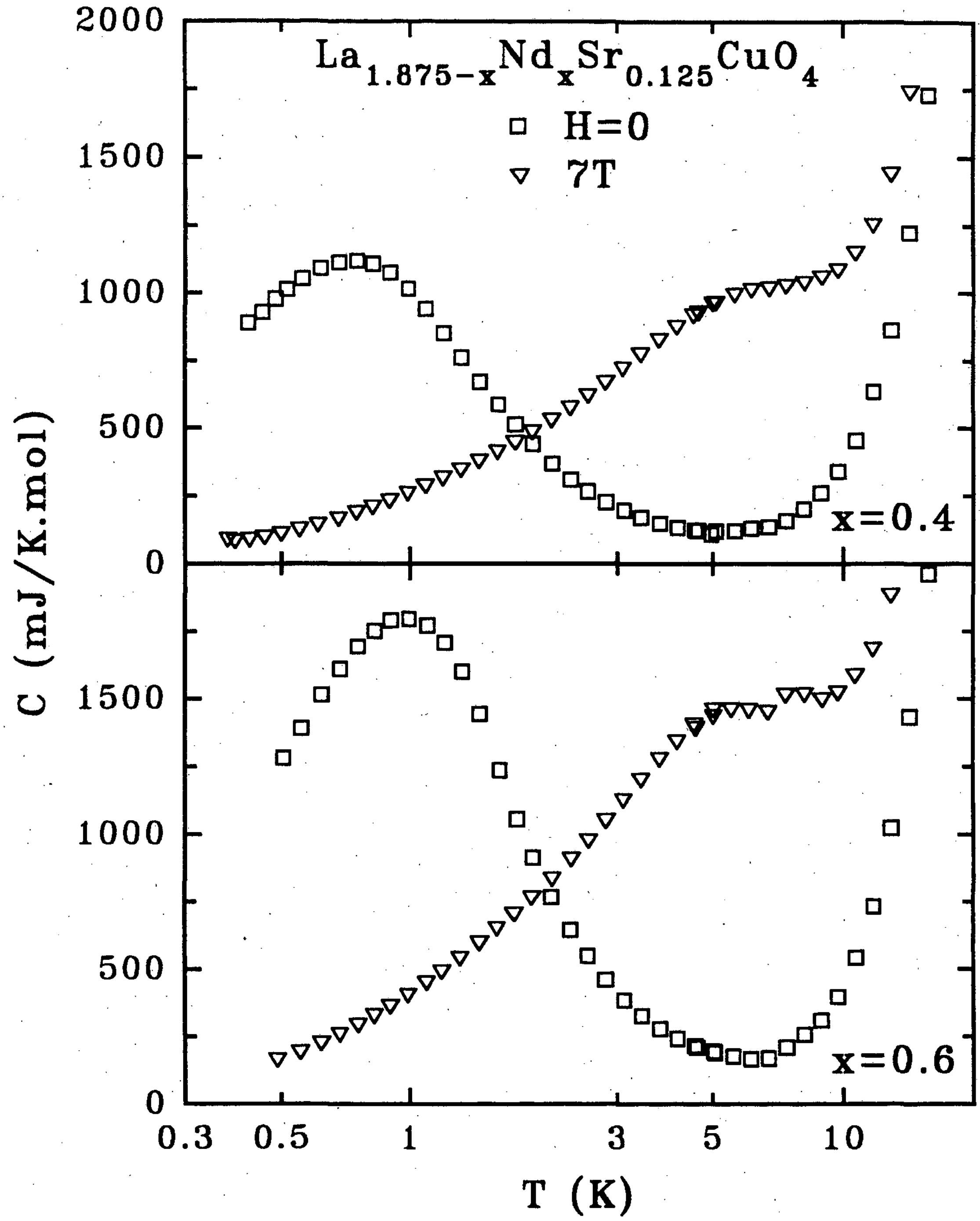


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FIGURE 4

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