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

D.A. Wright, R.A. Fisher, N.E. Phillips, M.K. Crawford,
and E.M. McCarron III

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by

D. A. WRIGHT*, R. A. FISHER*, N. E. PHILLIPS*,

M. K. CRAWFORD+ and E. M. McCARRON III+

**Materials Sciences Division*
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720, USA

+E. I. DuPont de Nemours and Co.
Wilmington, DE 19880, USA

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

D.A. Wright*, R.A. Fisher*, N.E. Phillips*, M.K. Crawford+, and E.M. McCarron III+

*Lawrence Berkeley Laboratory, and mail address: Department of Chemistry, University of California, Berkeley, CA 94720 USA
+E.I. duPont de Nemours Co., Wilmington, Delaware 19808 USA

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 $0.2 \leq x \leq 0.6$, 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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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.

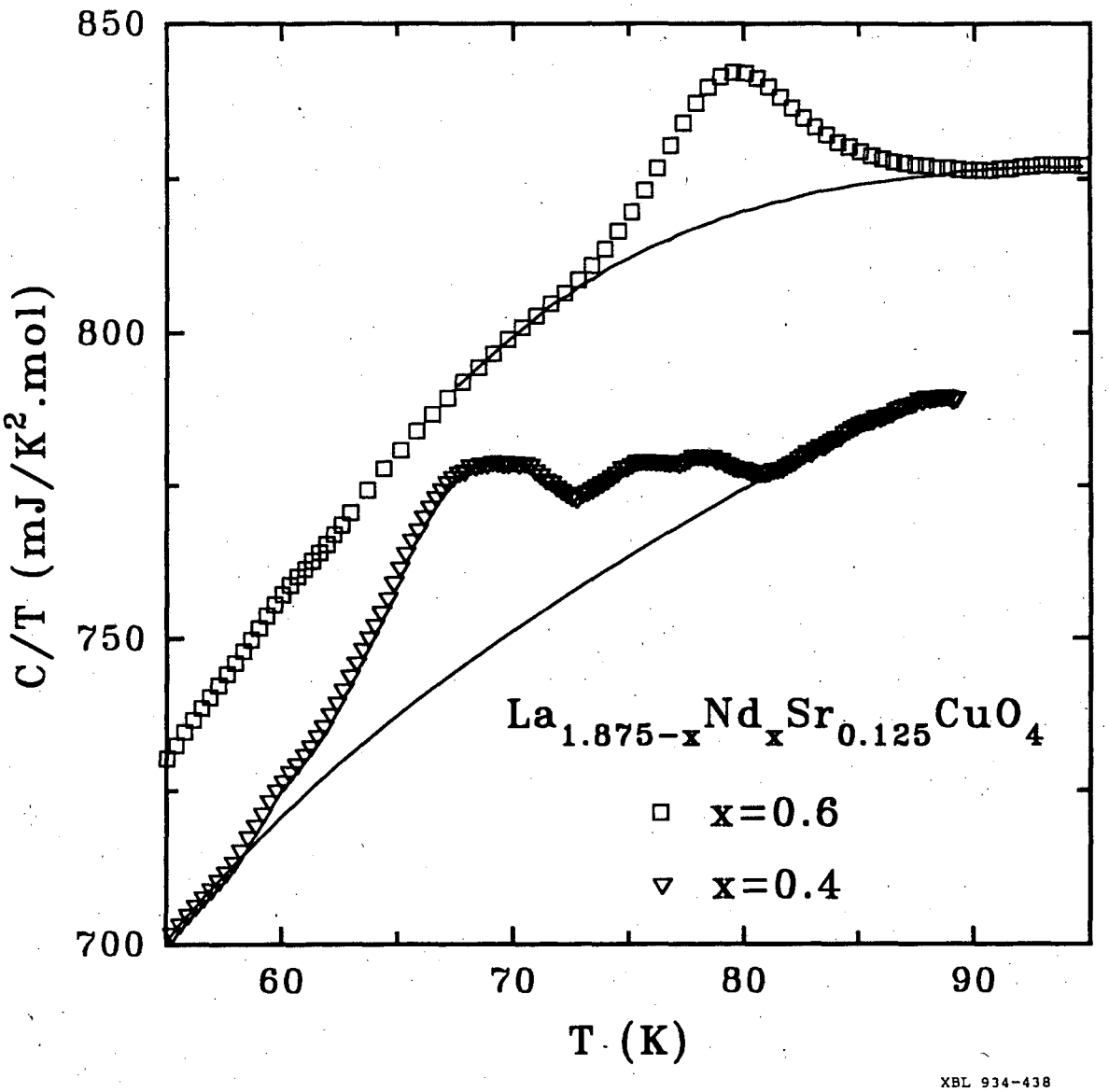
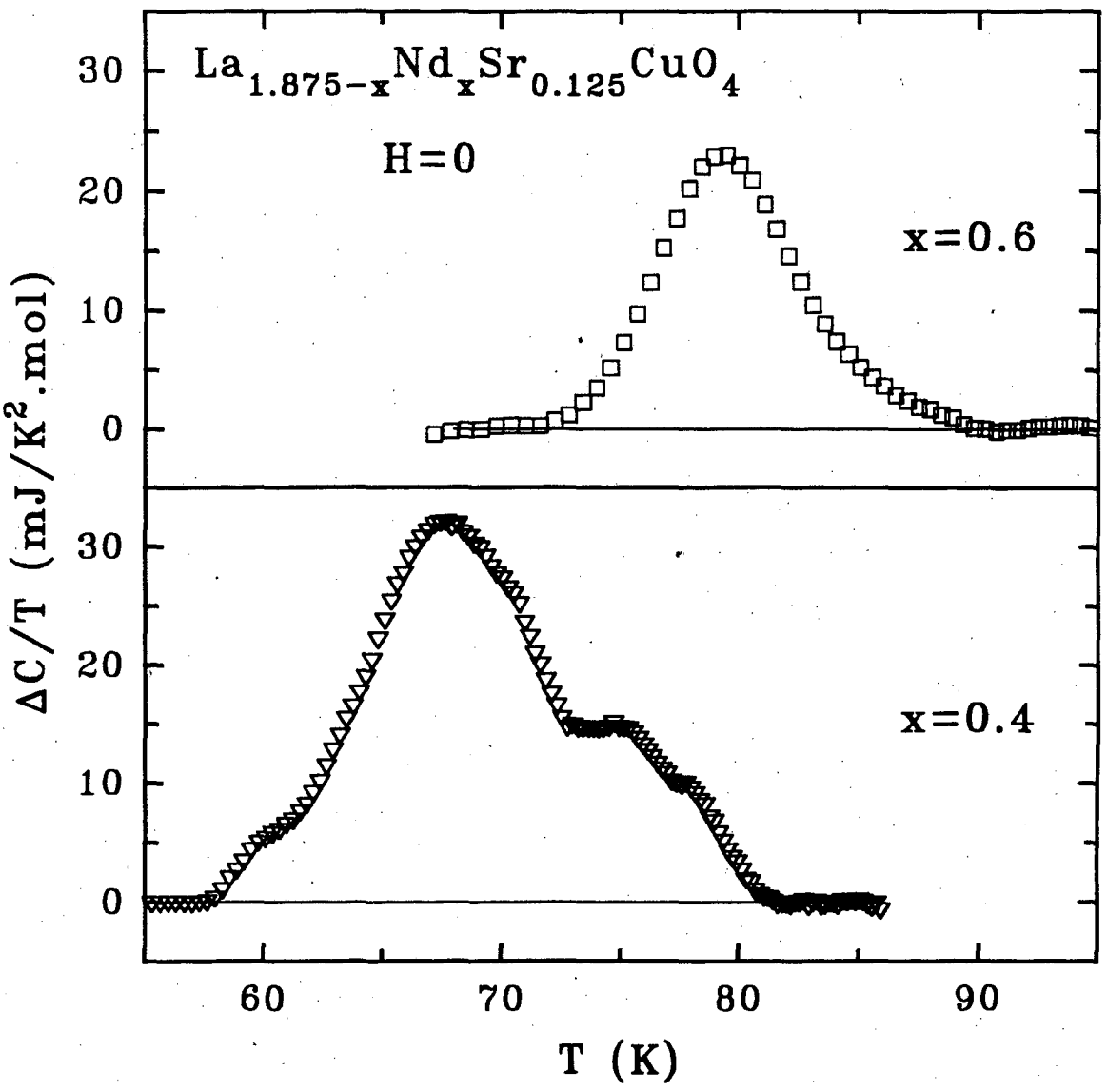

850
800
750
700
C/T (mJ/K^2.mol)
60
70
80
90
T (K)
$La_{1.875-x}Nd_xSr_{0.125}CuO_4$
x=0.6
x=0.4
XBL 934-438

FIGURE 1



XBL 934-439

FIGURE 2

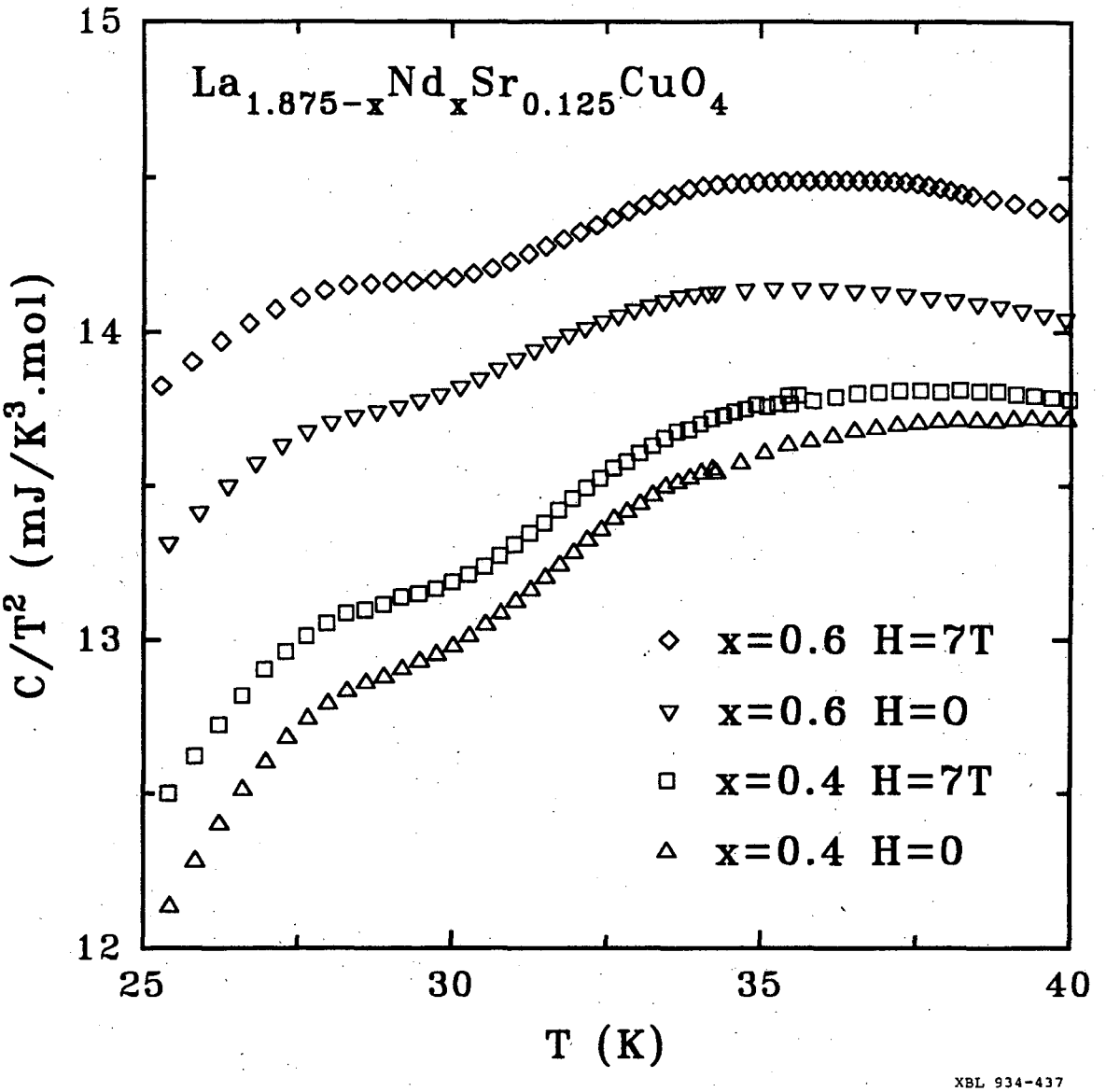

$La_{1.875-x}Nd_xSr_{0.125}CuO_4$
15
14
13
12
25
30
35
40
C/T^2 (mJ/K^3.mol)
T (K)
x=0.6 H=7T
x=0.6 H=0
x=0.4 H=7T
x=0.4 H=0
XBL 934-437

FIGURE 3

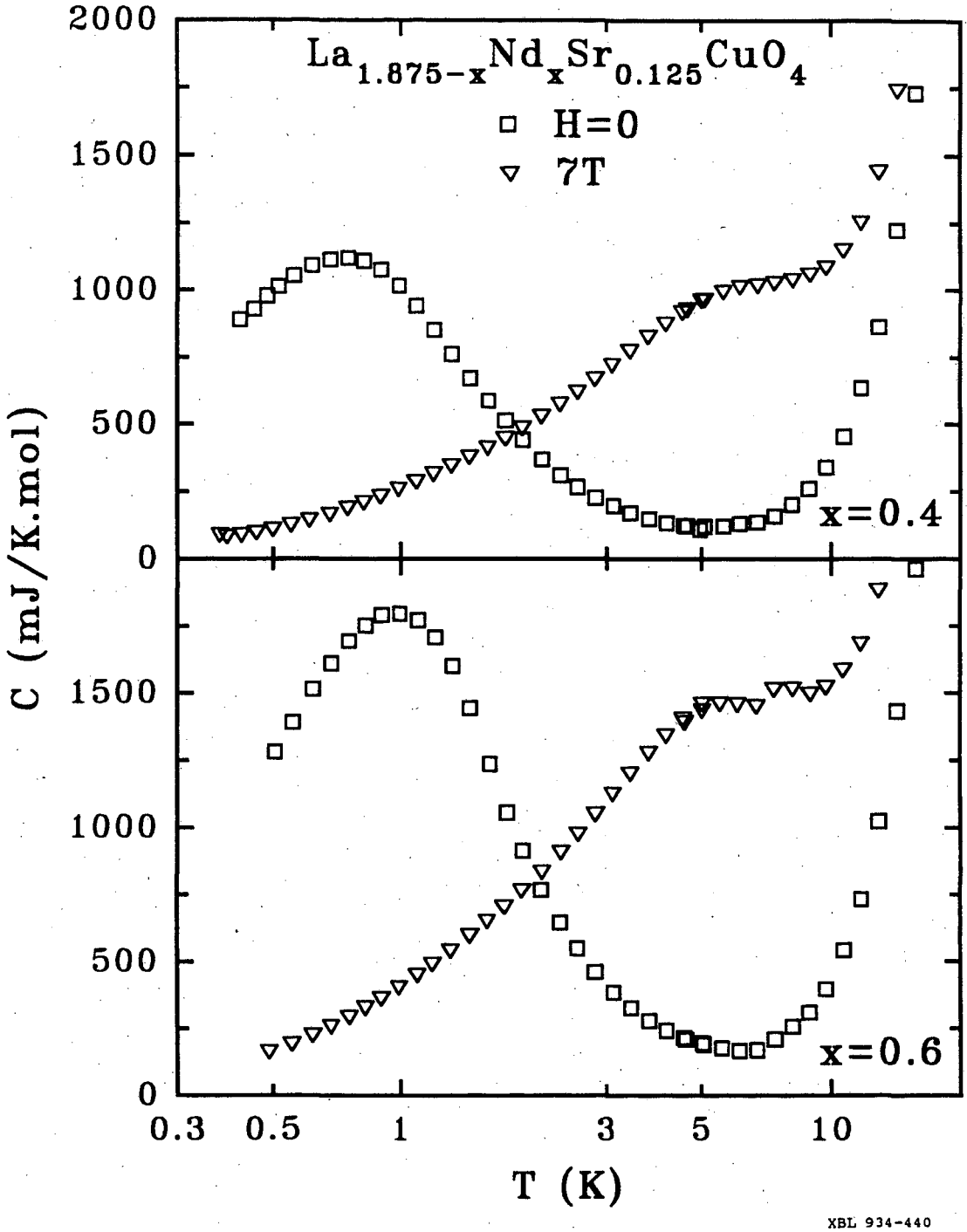

$La_{1.875-x}Nd_xSr_{0.125}CuO_4$
H=0
7T
x=0.4
x=0.6
C (mJ/K.mol)
T (K)
2000
1500
1000
500
0
0.3
0.5
1
3
5
10
XBL 934-440

FIGURE 4

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