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SPECIFIC HEAT OF THE HIGH-T_C SUPERCONDUCTOR (BI_{1.66} PB_{0.34}
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To be presented at the Conference on Materials and Mechanical Properties of
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Specific Heat of the High- T_c Superconductor $(\text{Bi}_{1.66}\text{Pb}_{0.34})\text{Ca}_2\text{Sr}_2\text{Cu}_3\text{O}_{10}$

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H.M. Ledbetter, and K. Togano

June 1989

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SPECIFIC HEAT OF THE HIGH- T_c SUPERCONDUCTOR $(\text{Bi}_{1.66}\text{Pb}_{0.34})\text{Ca}_2\text{Sr}_2\text{Cu}_3\text{O}_{10}$

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The specific heat (C) was measured for $H=0$ and 7T in the ranges 0.4 to 20K and 65 to 125K. The coefficient of the low-temperature linear term in C was 0 ± 0.5 mJ/K²·mole. On initial cooling, an anomaly in C was observed at T_c , but there were dramatic temperature hysteresis effects.

Samples in the Bi-Ca-Sr-Cu-O system¹ usually consist of mixtures of compounds with T_c 's in the range 80 to 115K. Nearly pure single phase material can be synthesized with $T_c \sim 107$ K by partial substitution of Pb for Bi.² In this paper we report measurements of C on a $(\text{Bi}_{1.66}\text{Pb}_{0.34})\text{Ca}_2\text{Sr}_2\text{Cu}_3\text{O}_{10}$ sample which had previously been used for elastic constant measurements.

Field-cooled susceptibility (χ_v) measurements were made on a cylinder ($d/h=0.45$) cut from the calorimetric sample with the measuring field applied at 130K. χ_v , corrected for demagnetizing effects, is shown in Fig. 1. Points labeled 1 were taken on the initial cool-down; points labeled 2 were taken after re-warming to 130K; and points labeled 3 were taken after again re-warming to 130K and exposure to 5T at that temperature. Hysteresis effects have also been observed in elastic-constant measurements.³

χ_v was measured from 110 to 300K in 2T. The data are plotted in Fig. 2 where the straight line is the least-squares fit to the indicated Curie-Weiss law. Assuming $S=1/2$ and $g=2$, a paramagnetic impurity fraction $[n_i(\chi)]=0.020$ was calculated from α .

C/T vs T^2 in the low-temperature region is plotted in Fig. 3. At $H=0$ the upturn in C/T is associated mainly with the onset of magnetic impurity ordering, which in 7T produces a Schottky-like anomaly. By evaluating the entropy associated with the 7T anomaly, and assuming $S=1/2$, the impurity fraction $n_i(C)=0.018$, in good agreement with $n_i(\chi)$. In 7T, hyperfine interactions, primarily that of H with the nuclear magnetic moments of Bi and Cu, but including a Bi quadrupole term, account for the low-temperature upturn in C/T . The measured $C_{hf}(7T)T^2=1.5$ mJ/K²·mole is in good agreement with measurements

by Caspary et al.⁴ At H=0 the data in the range $3 \leq T \leq 12\text{K}$ were fit by:
 $C(H=0) = 260/T^2 + 0.5T + 2.49T^3 + 0.0277T^5 - 0.000101T^7$ with an rms deviation of 0.333%.
 $\gamma(0) = 0 \pm 0.5 \text{ mJ/K}^2 \cdot \text{mole}$ to within the accuracy of the data, similar to values
found previously for Pb-free Bi-Ca-Sr-Cu-O superconductors.⁵ $\theta_0 = 246\text{K}$. No
hysteresis was observed in the $T < 20\text{K}$ data.

Measurements of C, in H=0, following initial cool-down exhibited the
anomaly shown in Fig. 4, where the horizontal bar is ΔT_c from the 10-90%
transition in χ_v . Subsequent measurements in both H=0 and 7T, made without
heating the sample above 130K, had run-to-run variations as large as 20%.
After warming to room temperature and re-cooling, the first measurement
reproduced the original one, while subsequent determinations were again
erratic. This hysteresis is no doubt connected with those in the Meissner-
effect and elastic-constant³ data. The vertical line in Fig. 4 represents an
ideal entropy conserving transition at $T_c = 104\text{K}$, from which $\Delta C(T_c)/T_c = 37$
 $\text{mJ/K}^2 \cdot \text{mole}$. Assuming the BCS weak coupling limit, $\gamma = 26 \text{ mJ/K}^2 \cdot \text{mole}$.

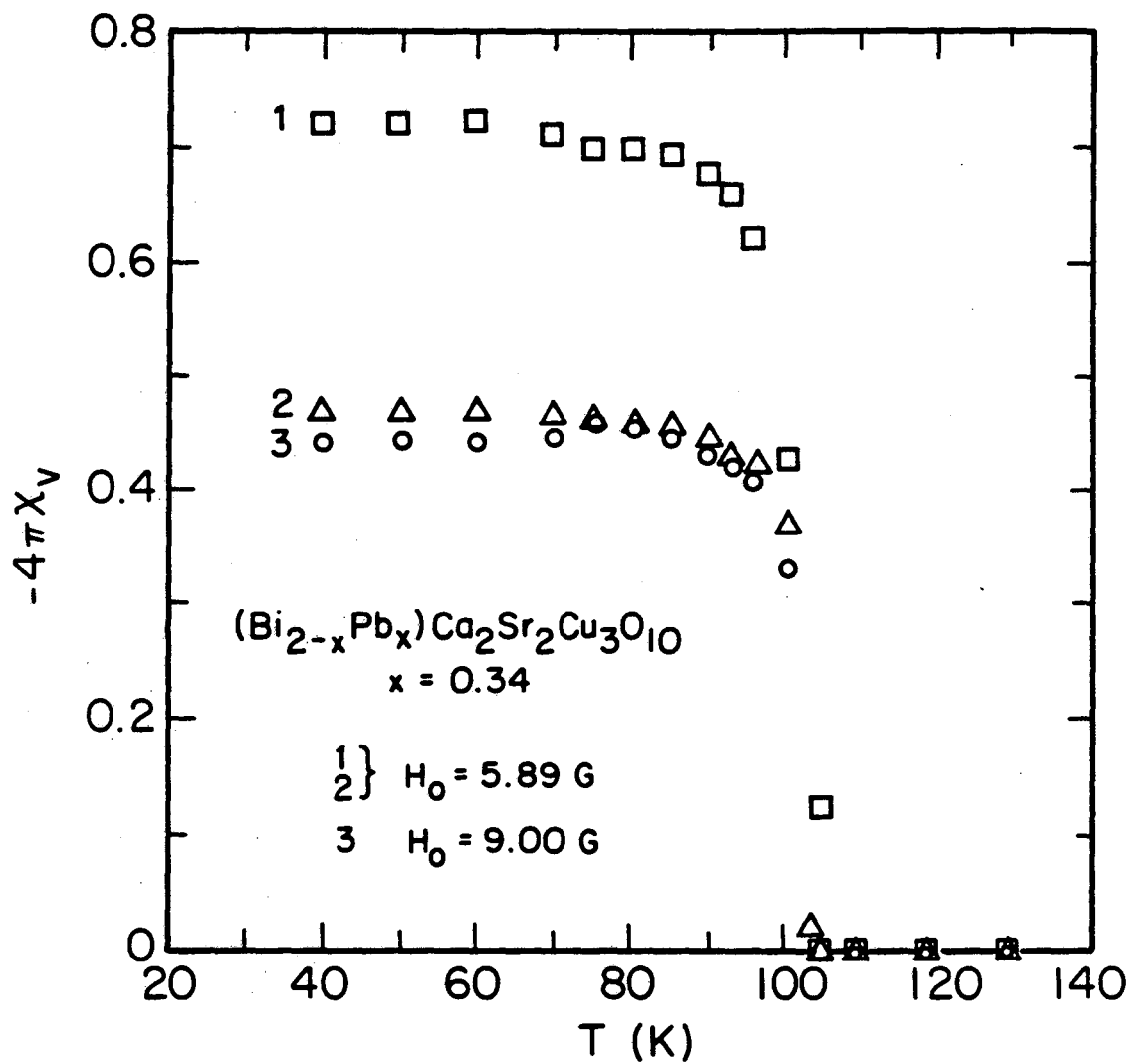
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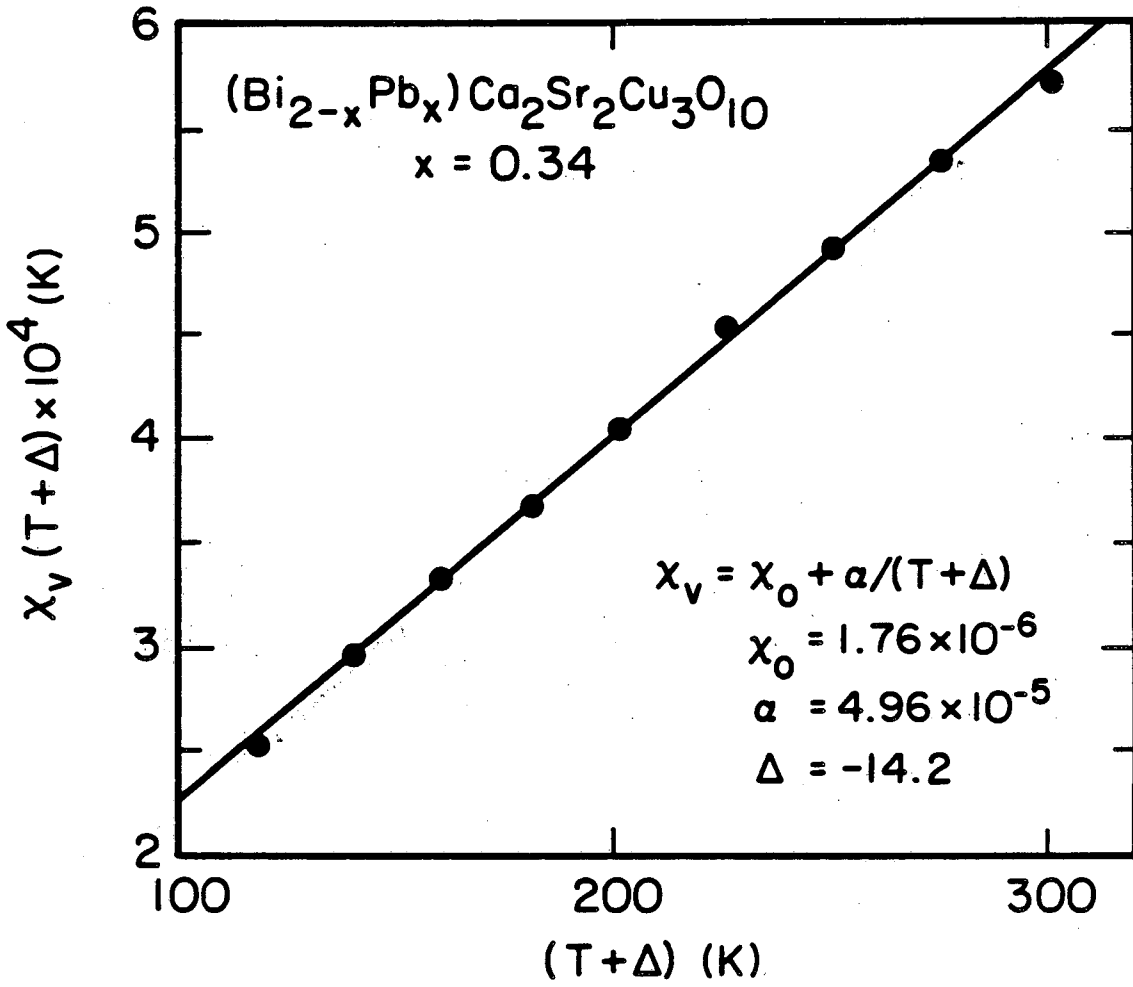
FIGURE CAPTIONS

1. Meissner fraction vs T showing hysteresis.
2. Fit of χ data above T_c to a Curie-Weiss law.
3. C/T vs T^2 in the low-temperature region.
4. C/T near T_c following initial cool-down.



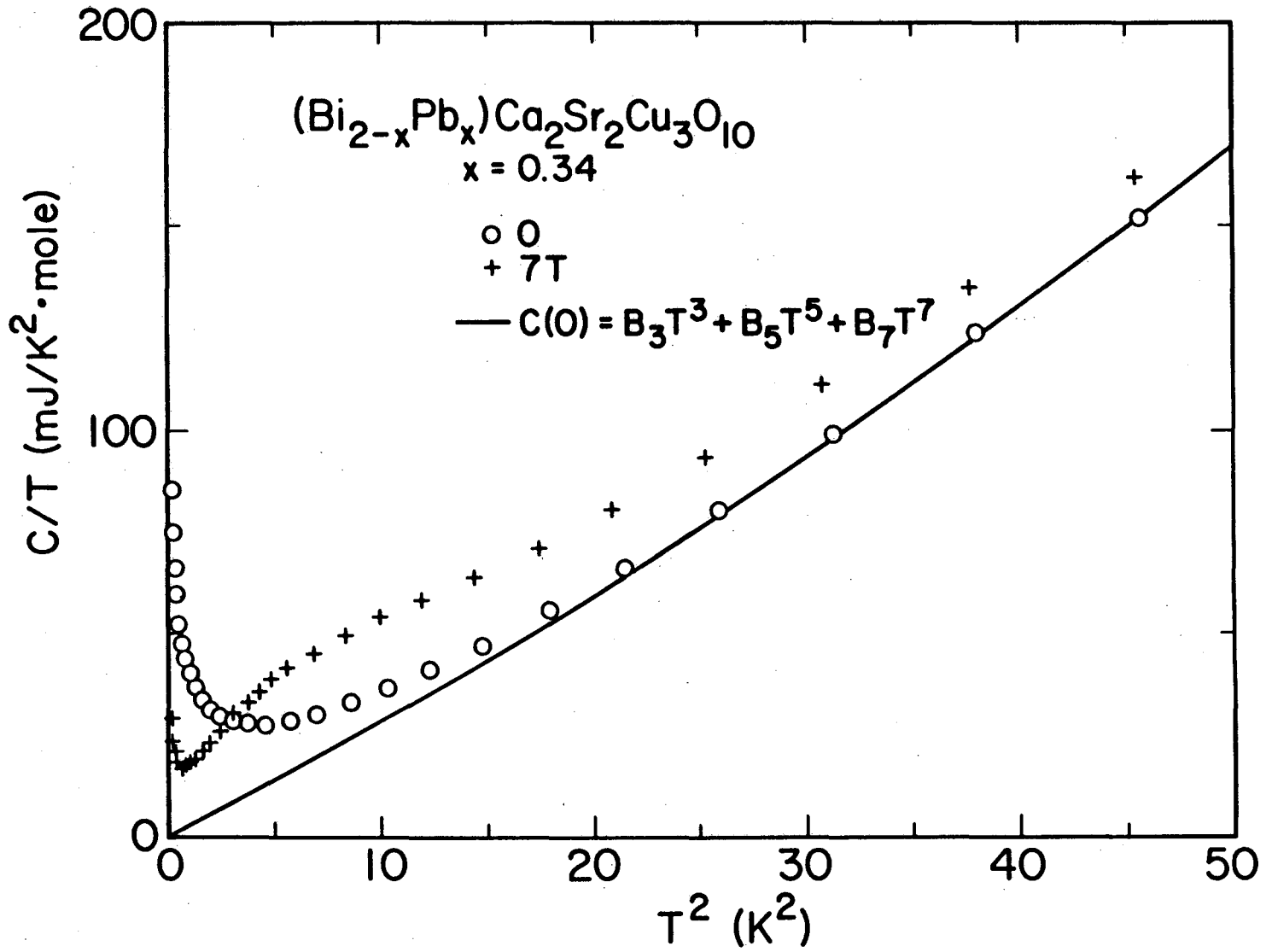
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Fig. 1



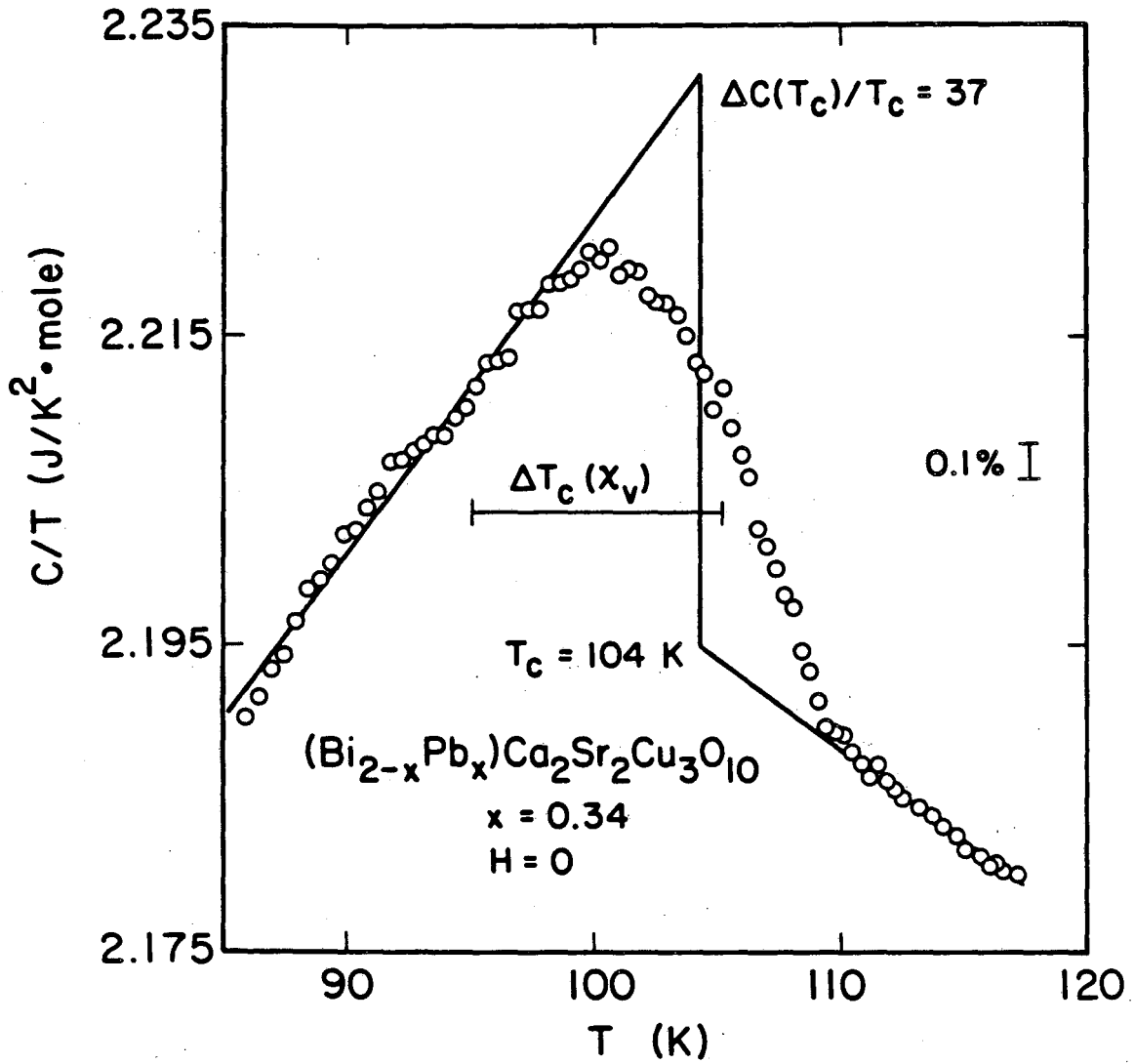
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Fig. 2.



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Fig. 3



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Fig. 4

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