Title
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Publication Date
1990-03-01

LBL-28750

Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

Materials & Chemical Sciences Division

To be presented at the XIX International Conference on Low Temperature Physics,
Brighton, Sussex, UK, August 16–22, 1990, and
to be published in *Physica B*

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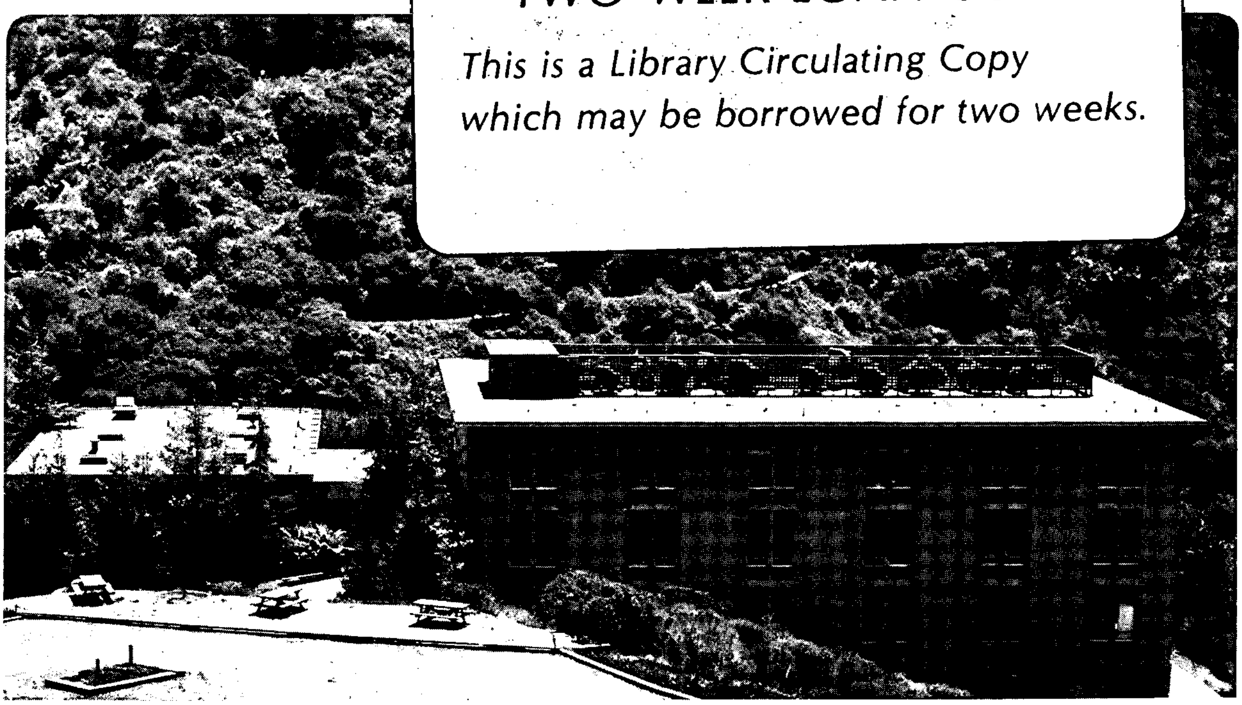
March 1990



Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.

DISCLAIMER

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This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Sciences Division of the U.S. Department Energy under contract DE-AC03-76SF00098. Additional support for A.A. was provided by a grant from the Swiss National Science Foundation.

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Specific heat measurements on $La_{1.85}Sr_{0.15}CuO_4$ show a linear correlation of the zero-field low-temperature linear term with the discontinuity at T_c, each of which provides a measure of the superconducting volume fraction. The correlation leads to an estimate of the normal-state density of electronic states which, together with the band structure calculated value, gives an electron-phonon interaction parameter that is too small to account for the superconductivity. For a sample with $x = 0.30$ a magnetic field insensitive anomaly in specific heat near 45K was observed which may be related to a structural phase transition.

We report specific heat (C) measurements for two polycrystalline samples of $La_{2-x}Sr_xCuO_4$ [(L,S)CO] with x=0.15 (superconducting) and x=0.30 (metallic, non superconducting) in the range $0.4 \leq T \leq 50K$ and for H=0 and 7T. The low temperature data for H=0 are shown in Fig. 1, together with that for a previously measured sample (1). The curves represent least-square fits of the data with $C=A_{-2}T^{-2}+\gamma(0)T+B_3T^3+B_5T^5$, but do not include the $A_{-2}T^{-2}$ term. Above ~5K there is a marked deviation from the T^3 behavior. Both of the x=0.15 samples have similar B_3T^3 terms, B_3=0.167 and 0.168 mJ/mole·K^4, corresponding to limiting low-temperature Debye characteristic temperatures of θ_0=434 and 433K, respectively, while B_3=0.105 mJ/mole·K^4 and θ_0=506K for x=0.30. As is typical for (L,S)CO the values of $\gamma(0)$ and the low-temperature upturns in C/T are an order of magnitude smaller than for most $YBa_2Cu_3O_7$ (YBCO) samples. Figure 2 is a plot of the data in the high temperature region. The insert shows [C(0)-C(7T)]/T for x=0.15 with the usual ideal entropy conserving construction at T_c=36K. For x=0.30, but not for x=0.15, there is an anomaly near 45K that is independent of magnetic field to 7T. This anomaly is similar to one found for $La_{1.85}Ba_{0.15}CuO_4$ by Loram et al. (2) near 58K that Axe at al. (3) associated with an orthorombic-to-tetragonal structural phase transition.

It has recently been shown (4) that for YBCO $\gamma(0)$ can be separated into two components : one due to impurities (most probably $BaCuO_2$) and the other due to non-superconducting normal material. Furthermore, there is a linear correlation between $\Delta C(T_c)$ and that component of $\gamma(0)$ due to an incomplete transition to the superconducting state. Since $BaCuO_2$ is not present in (L,S)CO, and assuming that other impurity phases make negligible contributions to $\gamma(0)$, the correlation can be tested directly. Data for six (L,S)CO samples with $x=0.15$, for which both $\Delta C(T_c)$ and $\gamma(0)$ have been measured, are represented by solid symbols in Fig. 3 and listed in Table 1. In addition, three values of $\gamma(0)$ for normal (L,S)CO, $x=0.30$, have been scaled to values appropriate to $x=0.15$, by using the empirically derived linear relationship (5) between γ and x ($\gamma/x=28$ mJ/mole$\cdot$K^2), and are represented by open symbols at $\Delta C(T_c)=0$ and listed in Table 1. Within substantial uncertainties, the straight line represents the data and suggests a model for which $\Delta C(T_c)$ measures the volume fraction of superconductivity (f_s) and $\gamma(0)$ measures the volume fraction of normal material ($1-f_s$). For $f_s=1$, $\Delta C(T_c)/T_c=14$ mJ/mole$\cdot$K^2 and for $f_s=0$, $\gamma=4.4$ mJ/mole$\cdot$K^2. The band structure contribution to γ has been calculated (9) and gives $\gamma_{bs}=4.5$ mJ/mole$\cdot$K^2. From $\gamma=\gamma_{bs}(1+\lambda)$, $\lambda\approx 0$ which is inconsistent with the strong coupling implied by the ratio $\Delta C(T_c)/\gamma T_c=3.2$. Therefore, if the validity of both the model and the band-structure calculation is accepted, the coupling mechanism producing superconductivity in (L,S)CO is not primarily by the electron-phonon interaction.

For the sample measured previously (1) $d\gamma/dH=0.109$ mJ/mole$\cdot$K$^2\cdot$T and $f_s=0.65$. If it is assumed that at $T=0$ $\bar{H}_{C2}=\gamma/(d\gamma/dH)$, where $\bar{H}_{C2}$ is an appropriate average of the anisotropic H_{C2}, $\bar{H}_{C2}=26$T, compared with $H_{C2}=38\pm5$T extrapolated to $T=0$ from measurements (10) on a polycrystalline sample of (L,S)CO to 25T.

This work was supported by the Director, Office of Basic Energy Sciences, Division of Materials Sciences of the U.S. Department of Energy under contract DE-AC03-76SF00098. Additional support for A.A. was provided by a grant from the Swiss National Science Foundation.

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Table 1: Values of $\gamma(0)$, $\Delta C(T_c)/T_c$ and f_s for $La_{2-x}Sr_xCuO_4$. Units are mJ/mole$\cdot K_2$.

$\gamma(0)$	$\Delta C(T_c)/T_c$	f_s	Ref.
	x=0.15		
0.6	13 ± 1	0.9	6
1.54	9.9 ± 0.5	0.65	1
1.8	6 ± 2	0.59	7
1.9	7 ± 0.5	0.57	5
2	10 ± 2	0.55	8
3.8	3.1 ± 0.5	0.14	*
	x=0.30		
8.4(4.5)$^+$	-	0	5
8.7(4.35)$^+$	-	0	*
9.0(4.2)$^+$	-	0	6

$^+$ Values of $\gamma(0)$ in parentheses have been scaled to x=0.15 from those observed at x=0.30 by using the empirical relation $\gamma/x=28$ mJ/mole$\cdot K^2$ (Ref. 5).

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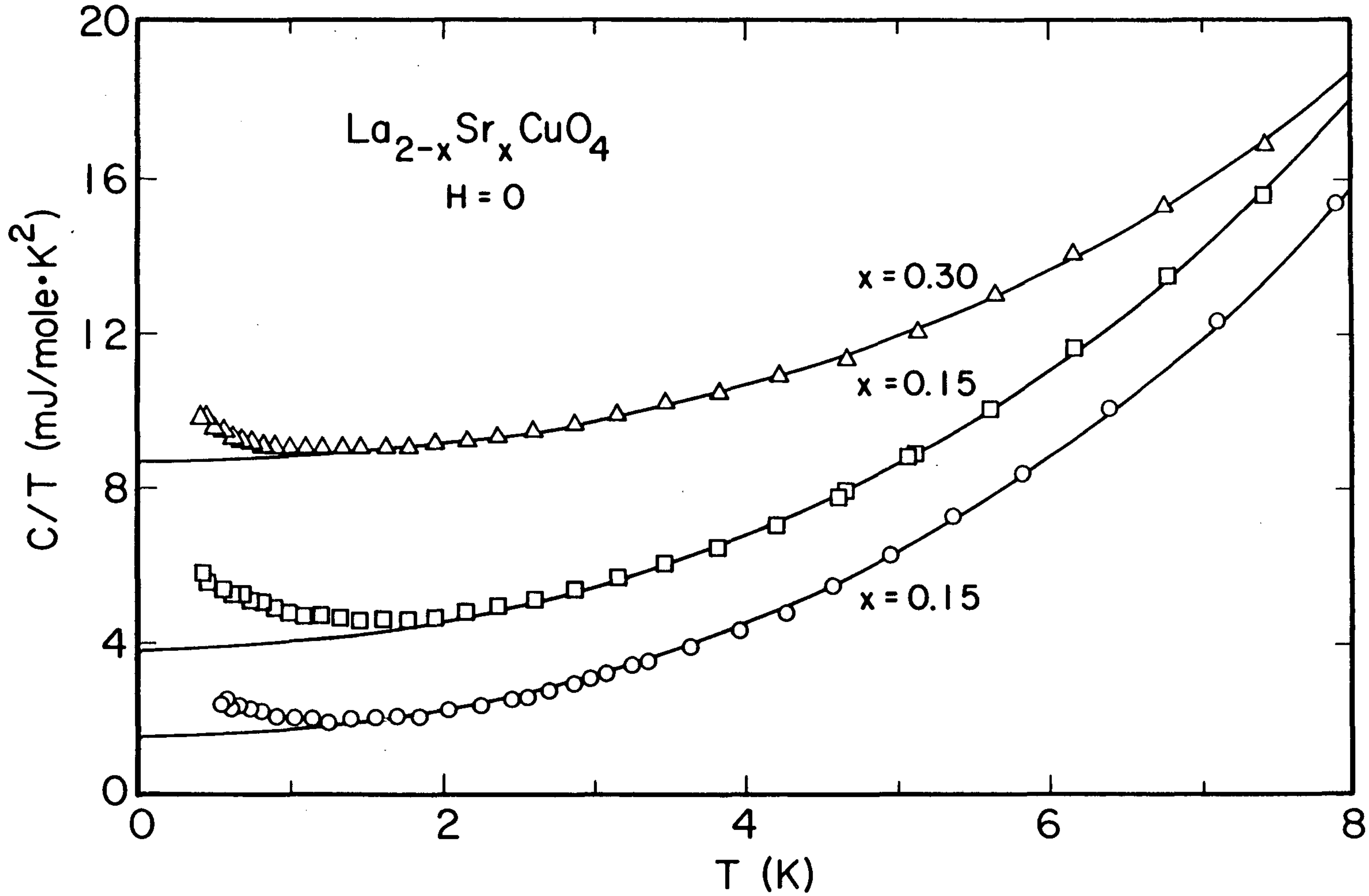

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FIGURE 1

C/T vs T for (L,S)CO. (○ denotes data from Ref.1).

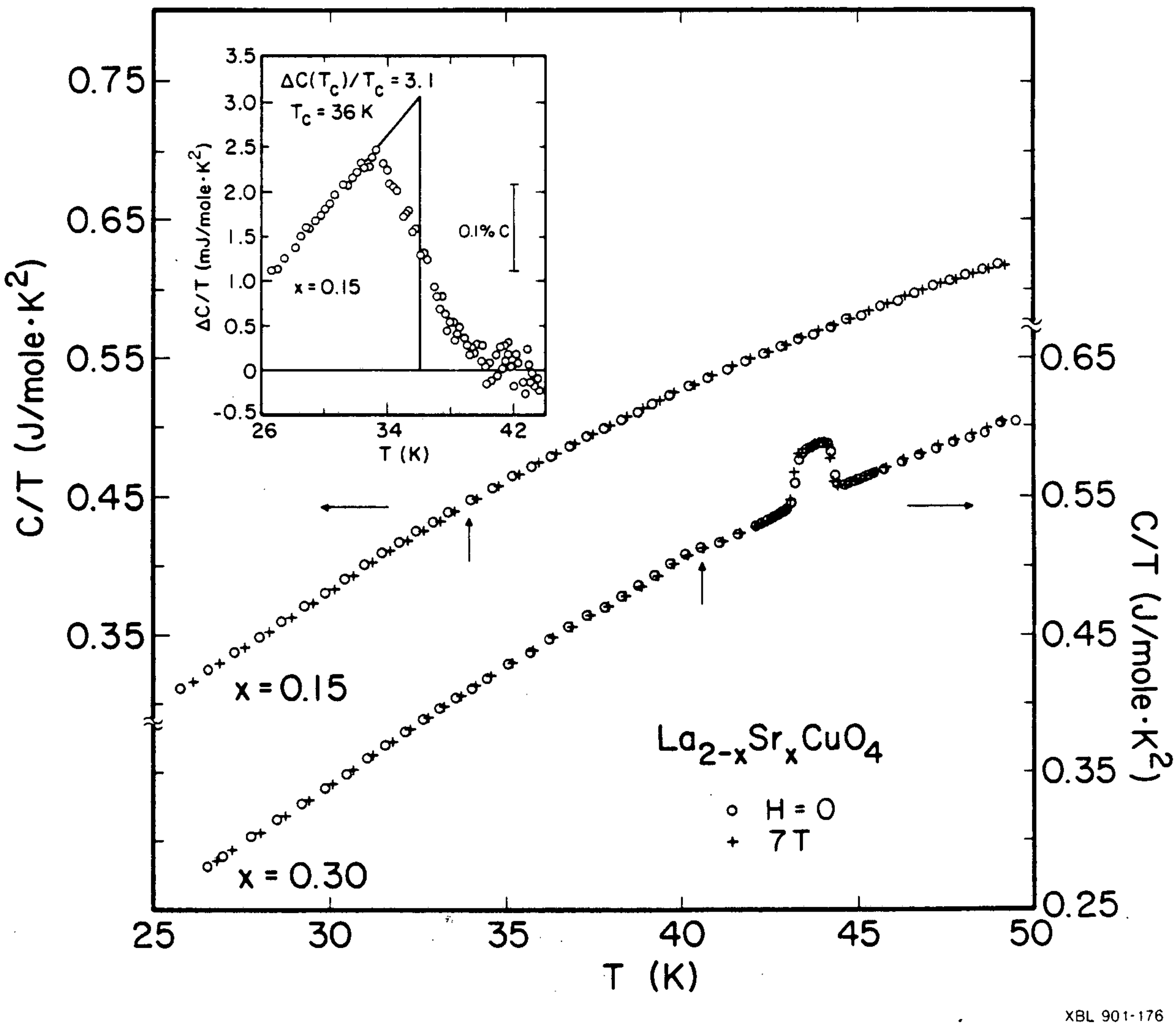

FIGURE 2

C/T vs T for (L,S)CO.

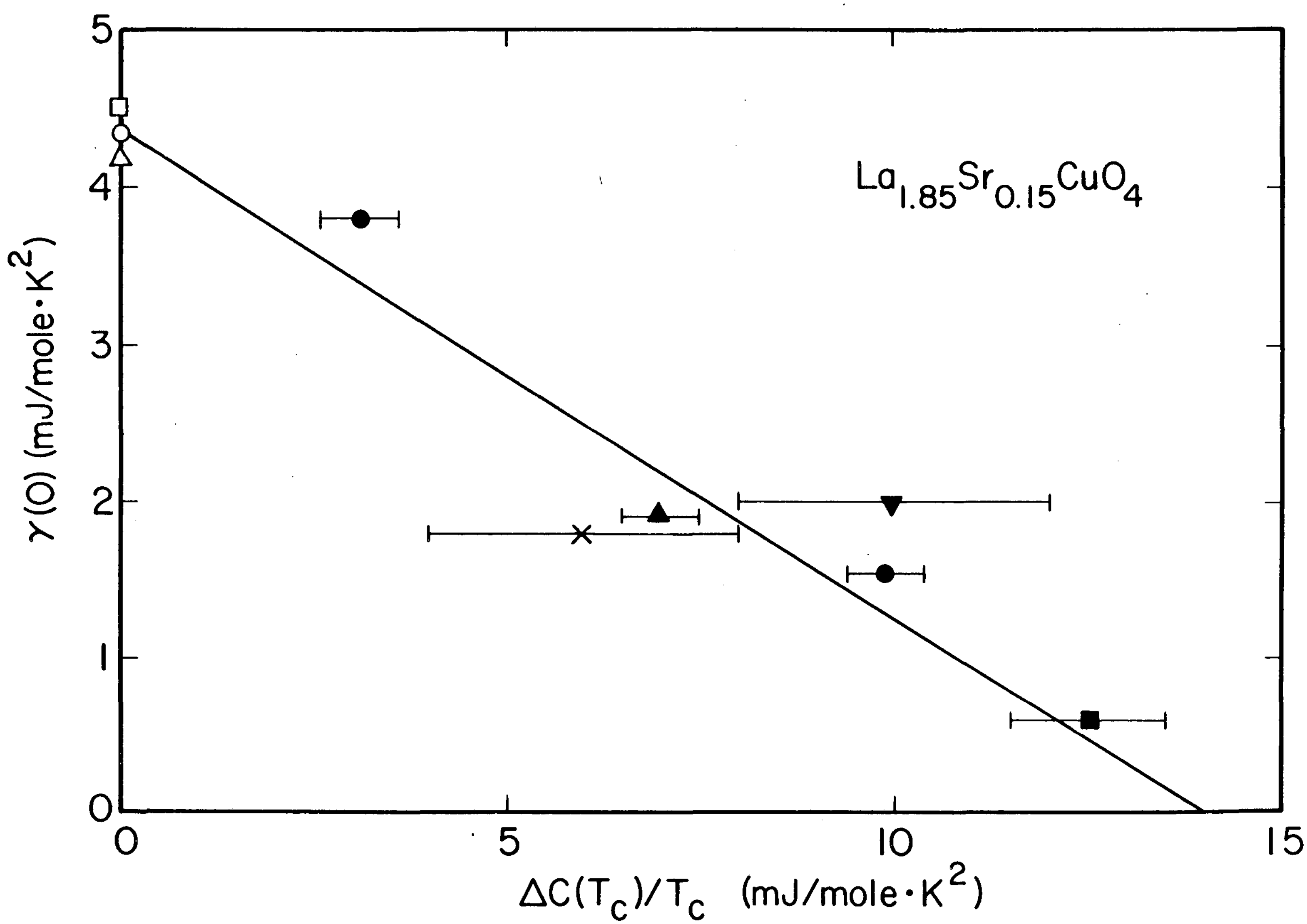

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FIGURE 3

$\gamma(0)$ vs $\Delta C(T_c)/T_c$ for (L,S)CO, x=0.15. (●,○ this work; ▲,△ Ref. 5:

,□ Ref. 6; ×, Ref. 7; ▿, Ref.8)

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