Comment on "Bulk Superconductivity at 91 K in Single-Phase Oxygen-Deficient Perovskite $Ba_2YCu_3O_{9-\delta}$"

The coefficient of the electronic specific heat, the Sommerfield constant γ, figures importantly in the properties of superconductors. Cognizant of this, Cava *et al.*[1] recently estimated γ for the ceramic superconductor $YBa_2Cu_3O_{9-\delta}$ from critical-field and paramagnetic-susceptibility data. They reported that the choice $3 \le \gamma \le 5$ mJ/(mole-Cu K^2) is consistent with available data. However, as part of our study[2] of the heat-capacity jump near T_c,[3] we found the data in that Letter to be inconsistent with such a choice. In particular, the temperature-independent paramagnetic susceptibility of $YBa_2Cu_3O_{9-\delta}$, as reported in the caption of Fig. 3 in Ref. 1, is $\chi_0 = 3.1 \times 10^{-4}$ emu/(mole-Cu Oe). The relationship between γ and the spin susceptibility in the free-electron model yields

$$\gamma = \tfrac{1}{3}(\pi k_B/\mu_B)^2 \chi_s = 23 \text{ mJ/(mole-Cu K}^2). \quad (1)$$

Core corrections increase this to 30 mJ/(mole-Cu K^2), outside the range reported by Cava *et al.*[1] by a factor of 6–10.

We comment here that a considerably larger value of γ, chosen to be consistent with the heat-capacity jump, leads to estimates that agree with measured values to within 20%. In Table I, we list the input parameters used in the analysis. Using these parameters and standard expressions[4] for type-II superconductors in the dirty limit, we report the critical fields and characteristic lengths for $YBa_2Cu_3O_{9-\delta}$ in Table II, along with measured values when available. The density of states corresponding to our choice for γ is $g(E_F) = 4.5$ states/(eV Cu-atom).

The density of states is rather large and the Ginzburg-Landau coherence length quite small. These imply a large effective-mass enhancement. If we take the density of carriers to be $n \simeq 9 \times 10^{21}$ cm^{-3}, as suggested by recent ac Hall measurements,[6] we find $k_F = 6.4 \times 10^7$ cm^{-1} and $m^*/m = 1.92 \times 10^5 \gamma/k_F = 9.0$. These values lead to a BCS coherence length of 12 Å and a transport mean free path $l_{tr} = 16$ Å, in agreement with ξ^d_{GL}. The calculated London penetration depth is about 1700 Å. Note that these give $r_s/a_0 = 5.6$ so that exchange effects should be very important. Including a Landau diamagnetic correction to the χ_s in Table II gives an exchange enhancement of 1.8.

TABLE I. Measured parameters.

Quantity	Value	Source
Resistivity at T_c, ρ	200 $\mu\Omega$ cm	Ref. 1
Sommerfeld constant, γ	3×10^3 erg/cm^3 K^2	This work
Critical temperature, T_c	90 K	Ref. 3
Specific heat jump, ΔC_p	4×10^5 erg/cm^3 K	Ref. 2

TABLE II. Comparison of quantities derived from the parameters of Table I with measured values. All quantities in the equations are in cgs units except ρ, which is in ohm centimeters.

Formula	Calculated value	Experimental value
$\xi^d_{GL}(0) = 8.6 \times 10^{-7}(\gamma\rho T_c)^{-1/2}$ cm	12 Å	
$\lambda^d_{GL}(0) = 6.4 \times 10^{-3}(\rho/T_c)^{1/2}$ cm	960 Å	≈ 1400 Å [a]
$\kappa^d_{Gl}(0) = \lambda^d_{Gl}(0)/\xi^d_{GL}(0)$	82	
$H_c(0) = 2.4\gamma^{1/2}T_c$ Oe	12 kOe	
$H_{c1}(0) = H_c(0)\ln(\kappa^d_{GL})/2^{1/2}\kappa^d_{GL}$	450 Oe	400 Oe [b]
$(dH_{c2}/dT)_{T_c} = -4.5 \times 10^4 \gamma\rho$ Oe/K	−27 kOe/K	−(13 to 50) kOe/K [c,d]
$\chi_s = 1.37 \times 10^{-9}\gamma$	4.1×10^{-6}	5.0×10^{-6} [e]
$\Delta C_p/\gamma T_c = 1.43$		1.48

[a]G. Aeppli, private communication.
[b]P. M. Grant, R. B. Beyers, E. M. Engler, G. Lim, S. S. P. Parkin, M. L. Ramirez, V. Y. Lee, A. Nazzal, J. E. Vazquez, and P. J. Savoy, Phys. Rev. B **35**, 7242 (1987).
[c]Reference 3.
[d]Reference 5.
[e]Reference 2.

These revised figures indicate that this high-temperature superconductor is well described by a weak-coupling, type-II superconductivity model, just at the dirty limit. The pair size is not yet comparable with the electron-electron distance—in short, there is nothing unusual in the results so far except the value of T_c.

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