Comment on "Universal Trends in Extreme Type-II Superconductors"

A recent Letter [1] has proffered the notion of a parabolic relationship between the superconductive critical temperature, T_c, and condensate density, n, of various substituted-compound superconductors. It was further assumed that n scales simply with penetration depth as $\lambda_\parallel^{-2}$ without any regard to variations in effective mass. Unfortunately, the approach adopted in Ref. [1] overlooks relevant information which would render its conclusions invalid. This Comment mentions the experimental evidence which contradicts the conjectured parabolic behavior.

The first conflict with experiment arises with the presumption of unique T_c's and uncompromised superconductive properties in off-stoichiometric compounds with depressed T_c. This premise is not generally supported by the work in Ref. [1] and considerable evidence refuting it was not cited. Behaviors characteristic of reduced superconductive quality, such as a diminished superconducting volume fraction, a rapid broadening of the specific heat jump at T_c, and a marked increase in the density of local Cu^{2+} moments, are reported for departures from optimum stoichiometry [2,3]. This is typical and expected from the naturally occurring statistical fluctuations in alloying compositions, particularly when coupled with the extremely short superconducting coherence distances. Any claim of "universal trends" in the measured superconducting properties of these materials should discuss this and include at least some data on each sample to show no degradation of superconductive quality (e.g., magnetization and specific heat [2]).

A second problem is in the interpretation of muon-spin-relaxation data for the vortex state. Since the corrections for fluxon pinning were not determined, depolarization rates, σ, bear no simple relationship to $\lambda_\parallel$ or n. Random distortions of triangular vortex lattices and magnetization inhomogeneities may increase the apparent σ, but dispersion of the vortex cores and longitudinal disordering in high-anisotropy superconductors have the opposite effect of decreasing σ [4]. The wide variability in pinning would also easily account for the range of σ values observed near optimal stoichiometry and T_c.

The most compelling argument against the authors' parabolic ansatz, however, can be seen in the data for $YBa_2Cu_3O_x$ for $x \lesssim 7$ and $T_c \approx 90$ K. In this case, the muon data cited in Ref. [1] and other results [5] allow 50% to 100% variations in $\lambda_\parallel^{-2}$ for T_c variations of only 2%. Reference [1] would predict for comparable variations in $\lambda_\parallel^{-2}$ a 25% variation in T_c, and hence does not apply in the limit of optimal T_c.

In summary, the conjectured dependence of T_c on doping has not been established owing to the mixed-phase behavior of nonoptimal stoichiometry. It is thus not surprising that the trends claimed in the pressure and isotope-effect coefficients also do not confirm a parabolic relationship between T_c and n. The added complication of widely varying pinning contributions and alloying disorder make the accurate determination of either the London $\lambda_\parallel$ or n in the nonoptimized materials impossible with the information available. We therefore conclude that "universal trends" among the intrinsic parameters have not been demonstrated in the Letter.

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[2] See, e.g., N. E. Phillips and R. A. Fisher, in *Proceedings of the University of Miami Workshop on Electronic Structure and Mechanisms for High-T_c Superconductivity, Miami, Florida, January 1991* (Plenum, New York, 1991); N. E. Phillips *et al.*, Physica (Amsterdam) **185-189C**, 1069 (1991); A. Amato *et al.*, Phys. Rev. B **43**, 11488 (1991); N. E. Phillips and R. A. Fisher, J. Magn. Magn. Mater. **90-91**, 589 (1990); A. Amato *et al.*, Physica (Amsterdam) **165-166B**, 1337 (1990); **165-166B**, 1347 (1990); N. E. Phillips *et al.*, Phys. Rev. Lett. **65**, 357 (1990); D. R. Harshman *et al.*, Phys. Rev. Lett. **63**, 1187 (1989).

[3] D. R. Harshman and A. P. Mills, Jr., Phys. Rev. B **45**, 10684 (1992), show that unambiguous universal expressions between the two-dimensional electronic parameters of the high-T_c superconductors are found only for the optimized materials exhibiting minimal disorder effects.

[4] D. R. Harshman *et al.*, Phys. Rev. Lett. **67**, 3150 (1991); Phys. Rev. B **47**, 2905 (1993).

[5] B. Janoussy *et al.*, Physica (Amsterdam) **181C**, 51 (1991).