Comment on "High-Resolution Photoemission Study of the Low-Energy Excitations Reflecting the Superconducting State of Bi-Sr-Ca-Cu-O Single Crystals"

A recent Letter by Imer *et al.*¹ confirms the photoemission detection of low-energy quasiparticle excitations reflecting the superconducting state of Bi-Ca-Sr-Cu-O, obtained earlier by our group.² Imer *et al.* quote our result with the comment "We believe that the spectral modifications . . . do not have the same origin" (as the effect they see). We challenge this statement as incorrect and misleading.

The work of Imer *et al.* merely corroborates our earlier results, since the data are equivalent (allowing for differences in temperature and resolution) as one can see from the spectra published in Refs. 1 and 2.³ From our results we derived a value of the superconductivity gap parameter, $\Delta = 30 \pm 15$ meV, which is confirmed by the estimate of Imer *et al.* We believe, however, that their quoted accuracy of ± 5 meV is an underestimate because of problems with normalization, with the approximations used in the data analysis, and with the role of the coherence length, which are discussed in our paper² but neglected or downplayed in Ref. 1.

The curve normalization is a crucial issue, in particular, because it affects the crossover point of the low- and high-temperature curves. For example, different normalization procedures can move the crossover point to energies above E_F . Because of this, the best evidence for the creation of a gap is the large decrease in the signal above E_F . With a gap parameter $\Delta = 30$ meV, model calculations like those presented in Refs. 1 and 2 predict a large decrease of up to 100 counts/sec with our experimental conditions and, in particular, with our resolution. A decrease of this magnitude can be easily detected, and in fact, it was detected in our experiment. On the other hand, such a large decrease is very difficult to explain without a gap of the magnitude derived by us and confirmed by Ref. 1.

The speculation by Imer *et al.* that the two effects "do not have the same origin" implies that other unspecified temperature effects exist in the photoemission spectra. No evidence is offered by the authors to support this hypothesis. They simply refer, without further comments, to a paper by Hillebrecht *et al.*⁴ which merely states that their measurements "down to $T = 30$ K showed . . . no hint of a superconducting gap." Since Ref. 4 does not refer to our work, we can only assume that it would disagree not only with our data, but with those of Imer *et al.* as well.

Finally, the data interpretation proposed by Imer *et al.* lacks microscopic justification. This is a crucial point,

since the analysis in terms of quasiparticle excitations is by no means trivial. We addressed this point in Ref. 2, developing a quasiparticle picture for the photoelectric effect in the superconducting state that justifies the interpretation of the data in terms of a gap in the quasiparticle spectrum. In particular, we pointed out that the simple renormalization of the one-electron density of states by the BCS factor $|E|/(E^2 - \Delta^2)^{1/2}$, which was assumed in Ref. 1, is obtained *only* if the density of states is constant in the neighborhood of E_F . In the general case, the photoemission spectrum is characterized by the BCS factor multiplied by the weighted average of the densities of states at energies $\pm E$ relative to E_F .

In summary, there is no evidence that the effect we reported² is different from that recently observed by Imer *et al.* The work of Ref. 1 qualitatively and quantitatively confirms our conclusion that a superconducting gap exists in the photoemission spectrum, and provides no evidence for any other effect.

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³The energy resolution of Ref. 1 is better than that of our earlier experiment, but our data demonstrate that the resolution was sufficient to establish the existence of this phenomenon. Incidentally, we note that the BCS model curve of Fig. 3 in Ref. 1 is not consistent with the quoted resolution (20 meV Gaussian FWHM), and corresponds to much higher instrumental or inhomogeneous broadening.

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