Comment on "Complete Fermi Surface Mapping of $Bi_2Sr_2CaCu_2O_{8+x}$(001): Coexistence of Short Range Antiferromagnetic Correlations and Metallicity in the Same Phase"

In a recent Letter [1] Aebi *et al.* have presented impressive photoemission data on Bi(2212). They have mapped the Fermi surface at nearly 6000 points in the wave-vector space and have found features that they have interpreted in terms of antiferromagnetic correlations resulting in a $c(2 \times 2)$ superstructure. In this Comment I wish to point out that their interpretation of the data in terms of short-ranged antiferromagnetic correlations is tenuous.

Note that short-ranged and dynamic antiferromagnetic correlation cannot give rise to a broken symmetry necessary for the $c(2 \times 2)$ superstructure. For this, an averaged staggered moment is necessary. There is no evidence for such averaged staggered moments for any of these superconductors in the metallic regime. Thus the additional set of sharp lines, presumably reflecting additional pieces of the Fermi surface, observed in their experiments, cannot be due to a superstructure generated by antiferromagnetic correlations.

The complex electronic self-energy that defines the quasiparticle dispersion must have a width in the momentum space that is proportional to the inverse of the antiferromagnetic correlation length which, at best, is a few lattice spacings long, judging from the experimental observations (nuclear magnetic resonance and neutron scattering) in similar superconductors; similarly, the width in the frequency space, proportional to the energy of these short-wavelength spin excitations, can be *as large as* a few tenths of eV. In such a situation, there cannot be well-defined kinematics that lead to the observations of Aebi *et al.* Electronic energy eigenvalues that define the dispersion must represent stationary states to a good approximation [2]. Contrary to their suggestion, the situation is not at all analogous to the low-energy electron-diffraction (LEED) patterns of superstructures, where the superstructure results from a symmetry that is truly different from the underlying lattice.

The paper by Aebi *et al.* does not contain enough detail for us to analyze the origin of their observations. I can only offer two *conjectures* [3] that can be tested. First, if we assume that the Fermi surface is not the large Fermi surface with an enclosed volume proportional to $(1 - x)$, where x is the carrier density, as in Luttinger's theorem, but a small Fermi surface of the doped Mott insulator, proportional to x, as was thought to be the case in the early days of high temperature superconductors [4], then, perhaps, the data can be understood; close to $(\pi/2, \pi/2)$ and symmetry related points, there would be pockets, and the resulting spectra could perhaps be reconciled with experiments. Alas, this interpretation already suffers from the blemish that in recent years, beginning with the pioneering work of Olson *et al.* [5], experimentalists have strongly argued that the observed Fermi surface satisfies Luttinger's theorem. A careful reexamination appears to be appropriate. The second conjecture is more mundane. It may very well be that the surface of Bi(2212) does undergo a genuine (2×2) surface reconstruction, not to be confused with the superstructure arising from the presumed antiferromagnetic correlations.

It would be very interesting to uncover the proper explanation of these remarkable experiments.

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[1] P. Aebi, J. Osterwalder, P. Schwaller, L. Schlapbach, M. Shimoda, T. Mochiku, and K. Kadowaki, Phys. Rev. Lett. **72**, 2757 (1994).

[2] I emphasize that sufficiently long-ranged antiferromagnetic correlations can certainly lead to a reasonably well-defined short-ranged structure, as can be seen from A. P. Kampf and J. R. Schrieffer, Phys. Rev. B **42**, 7967 (1990).

[3] For an alternative explanation in terms of a "ghost" Fermi surface, see P. W. Anderson, J. Phys. Chem. Solids **54**, 1073 (1993).

[4] See, for example, discussions in *High Temperature Superconductivity*, edited by K. S. Bedell et al. (Addison-Wesley, Redwood City, 1990).

[5] C. G. Olson, R. Liu, A.-B. Yang, D. W. Lynch, A. J. Arko, R. S. List, B. W. Veal, Y. C. Chang, P. Z. Jiang, and A. P. Paulikas, Science **245**, 731 (1989).