Hot Spots on the Fermi Surface of Bi₂Sr₂CaCu₂O₈₊δ: Stripes versus Superstructure

In a recent paper Saini *et al.* [1] have reported evidence for a pseudogap around $(\pi, 0)$ at room temperature in the optimally doped superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212). This result is in contradiction with previous ARPES measurements [2]. Furthermore, they observed at certain points on the Fermi surface hot spots of high spectral intensity which they relate to the existence of stripes in the CuO planes. They also claim [1,3] to have identified a new electronic band along Γ-M_1 whose one-dimensional character provides further evidence for stripes. We demonstrate in this Comment that all the measured features can be simply understood by correctly considering the superstructure (umklapp) and shadow bands which occur in Bi2212.

In Fig. 1 we plot the main Fermi surface (white) as determined from a tight binding fit to ARPES spectra [4], the $Q = \pm(0.21\pi, 0.21\pi)$ umklapps (blue, green) and the $G = (\pi, \pi)$ shadow band (gray). The intensity plot in Fig. 1 is obtained using the following relations [5]:

$$I_k = P_k + \alpha(P_{k+Q} + P_{k-Q}) + \beta P_{k+G}, \qquad (1)$$

$$P_X = e^{-\frac{1}{2}\left(\frac{X-k_F}{\eta}\right)^2}(|\cos(\phi)\cos(2\theta)| + |\sin(\phi)\sin(2\theta)|), \qquad (2)$$

where ϕ is the angle between k and X and θ the angle between X and Γ-M. The angular term simulates the polarization dependence of the measured intensity and is the simplest form consistent with the dipole
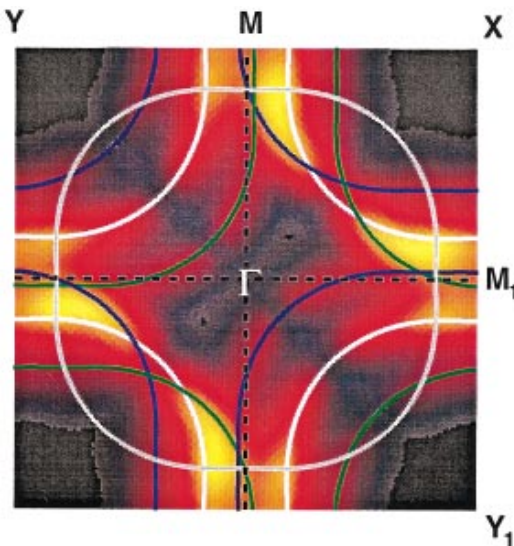

FIG. 1(color). Plot of the calculated intensity around the Fermi energy. Note the strong resemblance to Fig. 1 of Ref. [1].

selection rules. The smearing of the data due to the finite resolution is simulated by the parameter $\eta = 0.04\pi$ in the exponential. The factors $\alpha = 0.4$ and $\beta = 0.1$ represent the relative weights of the umklapp and shadow bands, respectively, chosen to be consistent with those discussed in earlier work [6,7]. Although our calculation uses a very simplistic matrix element, it contains the necessary ingredients to understand, on a semiquantitative basis, the measured spectra.

The effect of the selection rules is well observed along Γ-Y where no intensity is detected. There is spectral weight along Γ-X due to the umklapp bands. The hot spots are a consequence of the umklapp bands and therefore are not an indication of stripes or a pseudogap. In addition, the correct way to infer a pseudogap is to compare the leading edge of the ARPES spectrum to a Fermi function. Such ARPES measurements (including Fig. 2 of Ref. [1]) do not reveal the presence of a pseudogap above 100 K in optimally doped Bi2212 [2].

We now turn to the problem of the one-dimensional band [1,3]. As is obvious from Fig. 1, the crossing of the umklapp band and the Γ-M axis at $(0.4\pi, 0)$ is very sensitive to the sample alignment. We note that the M and M_1 points may appear to be inequivalent if the rotation axis and the sample's normal are not colinear. In that case and starting from the Γ-X direction, a $+45°$ (M) rotation is not equivalent anymore to a $-45°$ (M_1) rotation. We argue that this is what is responsible for the inequivalence seen in Ref. [1] and that the one-dimensional band is actually the umklapp band.

J. Mesot,[1,2] M. R. Norman,[1] H. Ding,[1,2] and J. C. Campuzano[1,2]
[1]Materials Science Division, Argonne National Laboratory Argonne, Illinois 60439
[2]Department of Physics, University of Illinois at Chicago Chicago, Illinois 60607

[1] N. L. Saini *et al.,* Phys. Rev. Lett. **79**, 3467 (1997).
[2] H. Ding *et al.,* Nature (London) **382**, 51 (1996).
[3] N. L. Saini *et al.,* Phys. Rev. B **57**, R11 101 (1998).
[4] M. R. Norman *et al.,* Phys. Rev. B **52**, 615 (1995).
[5] Equation (2) reflects the geometry of Ref. [1] where the photon polarization is parallel to k, not X.
[6] P. Aebi *et al.,* Phys. Rev. Lett. **72**, 2757 (1994).
[7] H. Ding *et al.,* Phys. Rev. Lett. **76**, 1533 (1996).