Comment on "Field Induced 3D to 2D Crossover of Shielding Current Path in $Bi_2Sr_2CaCu_2O_x$"

The authors of [1] interpret their magnetization data as evidence for a Bean-Livingston surface barrier determined by properties of the material. We want to comment on this and on similar papers which saw a surface barrier in high-T_c superconductors (HTSC); see references in [2,3]. It was often questioned that one can see the classical Bean-Livingston barrier in real crystals with sharp corners or irregular edges, since it is well known that one needs an extremely smooth surface to observe this barrier. Also, the surface of HTSC is covered by a poorly superconducting layer which suppresses this surface barrier. It was then argued that the Bean-Livingston barrier in HTSC is very high due to the large Ginzburg-Landau parameter, such that a marked effect of the barrier remains even after its reduction by surface irregularities. We suggest here an alternative explanation for the observed barrierlike phenomena in HTSC which is not so sensitive to surface imperfections and does not require bulk or surface pinning.

We think the barrier is of *geometric* origin, similar to the "edge shape barrier" discussed originally for type I superconductors with rectangular cross section in [4]. As compared to the "academic" ellipsoid, a realistic plate with constant thickness has larger screening currents caused by the additional material near the edges. After flux has penetrated nearly reversibly at the more or less sharp corners of the rectangular cross section, these additional screening currents hinder the flux from penetrating deeper until a higher penetration field H_p is applied. In *decreasing* field, the condition for flux exit is the absence of screening currents pushing vortices to the center, i.e., zero magnetization, as for the Bean-Livingston model.

This *macroscopic* entrance barrier is *not* sensitive to small defects on the surface, in contrast to the *microscopic* Bean-Livingston entrance barrier caused by image vortices. It will be influenced only by a large inhomogeneity over the sample size or by complete rounding of corners or thinning of edges. The magnetic curve produced by this barrier for a superconductor with small pinning has *the same characteristic shape* as discussed in [3]: The magnetization has a peak during field increase but is approximately zero during field decrease [4,5]. It is interesting that it was shown experimentally that in longitudinal geometry, when the magnetic field is parallel to a long superconducting cylinder, the edge shape barrier does not increase H_p considerably but still produces a big characteristic hysteresis which disappears after the cylinder corners are rounded [5].

From these arguments we can reestimate the anisotropy factor of [1] as follows: For *longitudinal* geometry, the edge shape barrier does not increase the penetration field considerably [4,5], and one has approximately $H_{c1}^{ab} = H_p/(1 - N_{ab}) = 7\,\mathrm{Oe}$. The lower critical field for penetration of vortices *perpendicular* to the *a-b* plane in Bi-Sr-Ca-Cu-O is (in the notation of [1]) $H_{c1}^{c} = H_{d\perp}/(1 - N_c) = 460\,\mathrm{Oe}$. Thus, the anisotropy parameter $\Gamma = \lambda_c/\lambda_{ab} \approx H_{c1}^{c}/H_{c1}^{ab} = 66$ is close to values obtained by other magnetic measurements and is not so high as the value of 700 obtained in [1].

For completeness we mention that a barrierlike effect at low temperatures [2], often taken as further evidence for the existence of the Bean-Livingston barrier in HTSC, can also be explained more naturally within the critical state model by accounting for the *perpendicular geometry and the rectangular cross section* of the superconductor [6]. There is ample experimental evidence for this from measured magnetization curves. Also, recent magneto-optic observations [7] revealed immediate penetration of flux directly to the center of clean $Bi_2Sr_2CaCu_2O_8$ crystals in a way characteristic of a surface barrier and observed before in type I superconductors [8], where only an edge shape barrier exists.

We conclude that the correct description of the magnetization process, taking into account the sample shape, can describe the observed appearance of barriers in both cases of weak pinning (edge shape barrier) and strong bulk pinning (critical state).

We thank John Gilchrist, Igor Landau, and Leonid Burlachkov for helpful discussions.

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Received 15 October 1993
PACS numbers: 74.25.Ha, 74.60.Ge

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0031-9007/94/73(12)/1731(1)$06.00