Koch, Foglietti, and Fisher Reply: As in the case of magnetic spin-glass systems, establishing unambiguously the presence or absence of a true glass phase is tricky. Nevertheless, on balance we believe that the data reported in Ref. 1 show strong evidence for a vortex-glass phase.

Provided the data near a continuous phase transition are within the critical regime they should scale appropriately with both universal exponents *and* universal scaling functions. The appropriate scaling of the current-voltage (I-V) characteristics, Eq. (1) in Ref. 1, can be verified by plotting V/I scaled by $|T-T_g|^{\nu(z-1)}$ vs I scaled by $|T-T_g|^{2\nu}$, at each temperature. The result at $H=4$ T for 119 I-V curves (ranging from $T=84.5$ to 72.7 K in 0.1-K intervals) of the sample reported in Ref. 1 with $\nu=1.7$ and $z=4.8$ is shown in Fig. 1. All the isotherms collapse nicely onto two curves ($T>T_g$ and $T<T_g$), consistent with scaling. The inset shows these same curves superimposed with data collapses for similar I-V data at $H=2$ and 3 T, each with the *same* exponents. Consistent with universality, all three sets of I-V data collapse onto the *same* (universal) scaling function. Moreover, I-V data taken since Ref. 1 on two new Y-Ba-Cu-O films (300 and 350 nm thick) show (for $H=4$ T) similar data collapses with the *same* exponents and scaling functions. At smaller fields scaling of the I-V curves generally degrades. This is expected[1] since the width of the critical regime must vanish as $H\rightarrow 0$. This naturally accounts for the different slopes in the $H=0.5$- and 4-T data noted by Coppersmith, Inui, and Littlewood,[2] rather than a lack of universality as they suggest. The exponent values ($z=4.8$ and $\nu=1.7$) are nicely in line with theoretical estimates for the vortex-glass transition. Extrapolating the first-order $\epsilon=6-d$ expansion gives $z=5$ and $\nu=1.1$.

Can all of these data be explained by a flux-creep-flow model as Coppersmith, Inui, and Littlewood suggest? The effective exponents needed to collapse the I-V curves in Coppersmith, Inui, and Littlewood's model ($z=13.5$ and $\nu=0.6$) imply that at $T=T_g$ the I-V curve would have the form $V=I^y$ with $y\equiv(z+1)/2=7.3$, which is far from the measured value of $y=2.9\pm0.3$ in all of the measurements we have made. Since the shape of the I-V curves and the effective exponents will not be universal in the flux-creep model, as noted by Coppersmith, Inui, and Littlewood, it is not clear to us how this model can account for the universality in the data (inset of our figure). Moreover, the I-V curves from the model only resemble the data if the dimensionless barrier height, $\gamma=U/k_BT$, is assumed to vary extremely rapidly with temperature, even well below the $H=0$ transition temperature of 90 K (γ spans a factor of 64 in the inset of their figure, whereas the data in Ref. 1 typically span only a 33% change in T). For this reason, Coppersmith, Inui, and Littlewood are forced to assume an empirical form, $U(T)=1/2(T_c-T)^x$, with $x=2.5$, a value much larger than in conventional flux-creep theory.

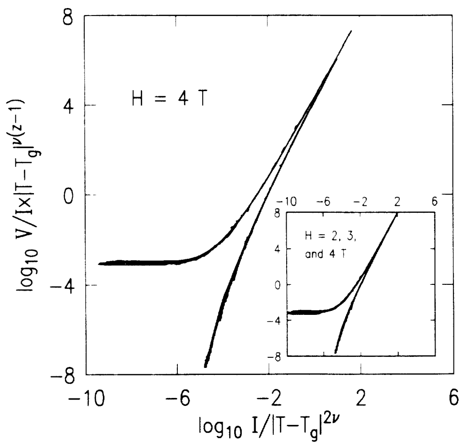

FIG. 1. Collapsed data plot of 119 I-V curves of the sample reported in Ref. 1, with temperature ranging from 84.5 to 72.7 K in 0.1-K intervals at $H=4$ T. Inset: Data superimposed with similarly collapsed I-V data at $H=2$ and 3 T. In each case $\nu=1.7$ and $z=4.8$.

Although the "data" collapse obtained by Coppersmith, Inui, and Littlewood appears at first glance to be comparable to our figure, closer inspection reveals otherwise. Specifically, Coppersmith, Inui, and Littlewood's figure reveals a systematic smearing near criticality (upper right of curves) not present in data. Moreover, in comparing the two figures it should be borne in mind that the collapse for the real data will invariably be degraded somewhat by noise, sample inhomogeneities, etc., which are not present in the numerics of Coppersmith, Inui, and Littlewood.

In sum, we believe that the current experimental data and their apparent scaling with universal exponents and scaling functions provides strong evidence for a transition into a vortex-glass phase, and is difficult to explain in terms of flux creep. Further dc I-V data over a larger dynamic range, as well as frequency-dependent transport measurements, would of course be useful in definitively settling this issue.

R. H. Koch, V. Foglietti, and M. P. A. Fisher
IBM Research Division
T. J. Watson Research Center
Yorktown Heights, New York 10598

Received 3 April 1990
PACS numbers: 74.60.Ge, 74.40.+k

[1] R. H. Koch, V. Foglietti, W. J. Gallagher, G. Koren, A. Gupta, and M. P. A. Fisher, Phys. Rev. Lett. **63**, 1511 (1989).
[2] S. N. Coppersmith, M. Inui, and P. B. Littlewood, preceding Comment, Phys. Rev. Lett. **64**, 2585 (1990).