Liu *et al.* Reply: Ao in his Comment [1] proposes an alternative to the model of vortex tunneling in the presence of strong damping which we used in our Letter [2] to explain the unusual temperature dependence of the resistance, $R = R_0 \exp(T/T_0)$, that we observed in ultrathin superconducting films. This temperature dependence holds over a wide range of normal-state resistances, including what Ao would term both the weak and the strong damping limits. Thus Ao's model would in principle be applicable only to that fraction of the films in the weak damping limit, whereas the one we used would apply to the remainder.

However, there are some difficulties with Ao's claim that Eq. (2) of his Comment can satisfactorily explain the data. He states that "there is no explicit dependence on the normal sheet resistance" in this equation. This contradicts the earlier statements within the Comment to the effect that the parameter v entering into Eq. (2) "decreases as disorder increases." Therefore, $\ln R_t$ as defined by Eq. (2) in fact *does* depend on the normal resistance R_N, but the Comment does not give explicitly the dependence. This result is inconsistent with the experimental finding that the parameter T_0 was independent of R_N.

In addition to the above, we have strong doubts as to the applicability of the concept of underdamped tunneling to the case of vortex motion in a superconducting film. Vortices in films *have* normal cores. Motion of these cores must cause dissipation. The existence of this dissipation is supported by the long history of studies of flux-flow resistance in superconducting films. The only known superconducting geometry in which vortex motion may be underdamped is that of an array of Josephson junctions [3], where vortices *do not* have normal cores. As long as vortices in films remain well-defined objects, they will have normal cores, and we believe that the overdamped model will describe their motion.

When films are made more and more resistive, the very fact that vortices are induced only by an external field becomes unclear. In particular, it was proposed [4] that the superconductor-insulator transition is driven by the spontaneous formation of free vortices. In our view, the fact that a film may have properties which place it far from the superconductor-insulator transition, rather than a particular value of its resistance, allows the use of the concept of vortices, and as long as this concept is applicable one can use the overdamped model. We would like to point out that even the most resistive films used in the experiments [2] were clearly very far from the insulating state.

In summary, it is our view that an analysis of data on the basis of an overdamped model of vortex tunneling is adequate if the superconducting films are sufficiently far from the transition to the insulating state.

This work was supported in part by Grants No. NSF/DMR-9001874 and No. NSF/DMR-9117341.

Y. Liu,[(a)] D. B. Haviland,[(b)] L. I. Glazman,[(c)]
and A. M. Goldman
School of Physics and Astronomy
University of Minnesota
Minneapolis, Minnesota 55455

Received 8 September 1992
PACS numbers: 74.60.Ge, 74.40.+k, 74.75.+t, 74.90.+n

[(a)]Present address: Department of Physics, University of Colorado, Box 390, Boulder, CO 80309.

[(b)]Present address: Department of Physics, Chalmers Technical University, S-412 96, Göteborg, Sweden.

[(c)]Also at the Theoretical Physics Institute, University of Minnesota, Minneapolis, MN 55455.

[1] Ping Ao, preceding Comment, Phys. Rev. Lett. **69**, 2997 (1992).

[2] Y. Liu, D. B. Haviland, L. I. Glazman, and A. M. Goldman, Phys. Rev. Lett. **68**, 2224 (1992).

[3] H. S. J. Van der Zant, F. C. Fritschy, T. P. Orlando, and J. E. Mooij, Phys. Rev. Lett. **66**, 2531 (1991).

[4] M-C. Cha, M. P. A. Fisher, S. M. Girvin, M. Wallin, and A. P. Young, Phys. Rev. B **44**, 6883 (1991).