Kantor, Kardar, and Nelson Reply: Recently we reported some results on statistical mechanics of two-dimensional networks.[1] Because of entropy effects, a self-avoiding manifold assumes a typical radius R that grows with its linear size L as $R \sim L^{\nu}$. Monte Carlo simulations in three dimensions lead to $\nu \sim 0.8$ in good agreement with a Flory estimate of $\frac{4}{5}$. For strips of width w and length L, we suggested a scaling form $R \sim (wL^3)^{1/5}$ which interpolates between $R \sim L^{4/5}$ for $w \sim L$ and $R \sim L^{3/5}$ for $w \ll L$. Note that $\frac{3}{5}$ is the Flory estimate for a *free polymer* in 3D. The crumpled balls obtained by crushing strips of paper[2,3] are *nonequilibrium* configurations that belong to an ensemble entirely different from the equilibrium ones mentioned earlier. Here we briefly remark on similarities and differences between these two ensembles, and present a simple explanation for the experimental results of the preceding Comment.[3]

Consider a D-dimensional manifold ($D=1$ for polymers, and $D=2$ for surfaces) crumpled under strong pressure in d dimensions. If the network collapses to a compact object whose fractal dimension equals the dimension d of space, the radius grows as $R \sim L^{\nu_c}$ with $\nu_c = D/d$ (since mass $\sim L^D \sim R^d$). A string of length L can easily be compacted in this fashion into a ball of radius $R \sim L^{\nu_1 = 1/3}$ in $d=3$. It is, however, much more difficult for *surfaces* to achieve this compaction without tearing.[4] This is why crumpled aluminum foils[1] and crushed pieces of paper[2,3] result in a nontrivial exponent $\nu_2 \approx 0.8 > \frac{2}{3}$. The interior of a crushed paper ball (seen by gently opening the ball) looks rather similar to pictures of free surfaces from Monte Carlo simulations, which may account for the similarity in the exponent ν for the two systems.

For the compacted strips of length L and width w studied by Gomes and Vasconcelos,[3] we would expect $R \sim w^{\alpha} L^{\beta}$ with an exponent that interpolates between compacted strings ($R \sim L^{1/3}$) for $L \gg w$, and crushed surfaces ($R \sim L^{\nu_2 \sim 0.8}$) for $L \sim w$. This leads to the conclusion $\alpha = \frac{1}{3} \sim 0.33$ and $\beta = \nu_2 - \frac{1}{3} \sim 0.47$. These exponents are quite consistent with the results reported in the preceding Comment.[3] Indeed, that agreement seems to improve for samples including a larger range of L/w, and hence more likely to be compacted to a uniform density.

This research was supported by the National Science Foundation through Grant No. DMR-86-20386 at the Massachusetts Institute of Technology, and through the Harvard University Materials Science Laboratory and Grant No. DMR-85-14638. One of us (M.K.) acknowledges receipt of an A.P. Sloan Fellowship.

Yacov Kantor
School of Physics and Astronomy
Tel-Aviv University
Tel-Aviv 69978, Israel

Mehran Kardar
Physics Department
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

David R. Nelson
Department of Physics
Harvard University
Cambridge, Massachusetts 02138

Received 16 November 1987
PACS numbers: 05.40.+j, 64.60.Fr, 82.65.Dp, 87.20.Cn

[1]Y. Kantor, M. Kardar, and D. R. Nelson, Phys. Rev. Lett. **57**, 791 (1986), and Phys. Rev. A **35**, 3056 (1987).

[2]M. A. F. Gomes, J. Phys. A **20**, L283 (1987).

[3]M. A. F. Gomes and G. L. Vasconcelos, preceding Comment [Phys. Rev. Lett. **60**, 237 (1988)].

[4]As discussed in Ref. 1, it is very difficult to "intelligently" fold a quasi-isometric self-avoiding surface into a compact object. We are familiar with only one such procedure, due to R. C. Ball (unpublished).