Comment on "Disorder and the Superfluid Transition in Liquid ^{4}He"

In a recent Letter Chan *et al.*[1] reported the observation of unusual scaling behavior near the superfluid transition of liquid ^{4}He in porous silica aerogels and xerogels, both for the case of thin films coating the substrates and for completely filled pores. Because the measured critical exponents differed considerably from those found in similar measurements using porous Vycor glass, they raised the interesting possibility that the transition in gels might be in a different universality class than the transition in Vycor. The purpose of this Comment is to point out that a calibration of the xerogel film data[1,2] shows that the transition temperature is related to the universal Kosterlitz-Thouless (KT) critical line in just the same manner as found previously in a calibration of the Vycor data.[3] This suggests a connection to recent vortex models[4] of the transition in multiply connected geometries, and provides a possible clue to understanding the exponent shifts in the gels as a changeover from Euclidean to *fractal* dimensionality.

The calibration of the xerogel film data[2] can be easily calculated from the raw data of Ref. 5. The ratio of the period shift ΔP of their oscillator to superfluid areal density σ_s is found to be $\Delta P/\sigma_s = 1.83\times10^{10}$ nsec cm^2/g. Multiplying this by the critical KT slope $\sigma_s/T = 3.5\times10^{-9}$ g/cm^{2}K yields a calibration of the data in terms of the critical KT line as $\Delta P/T = 63$ nsec/K, which is the slope of the line I have added to the data of Fig. 1(c). Figure 1 compares data for flat substrates, Vycor, and xerogel, and it is readily seen that the KT line is the common factor between them.[6] The broadening of the transition seen in the Vycor and xerogel data is predicted by the vortex models[3,4] to arise from the finite grain size, and this would account for the additional broadening of the xerogel transition compared with the Vycor, since the silica rods in the gel are thought to be of considerably smaller diameter than the ~150-Å Vycor grain size.

The change in the superfluid density exponent, from $\nu = 0.63$ in Vycor films to $\nu = 0.84$ in xerogel films, is likely due to structural differences between the two materials, as noted in Ref. 1. Vycor is characterized by a single length scale, the 150-Å grain size, whereas the silica gels are known from scattering experiments[7] to have a fractal distribution, with a fractal dimensionality D ranging between 1.8 and 2.4, dependent on sample preparation. The Ising model has been studied on fractal lattices,[8] where it was found that ν increased with decreasing D; it may be possible to formulate the vortex models[4,9] on a fractal lattice and see if a similar result holds. An important experiment would be to carry out both superfluid density and low-angle experiments on a series of samples to test if in fact there is a correlation between ν and D.

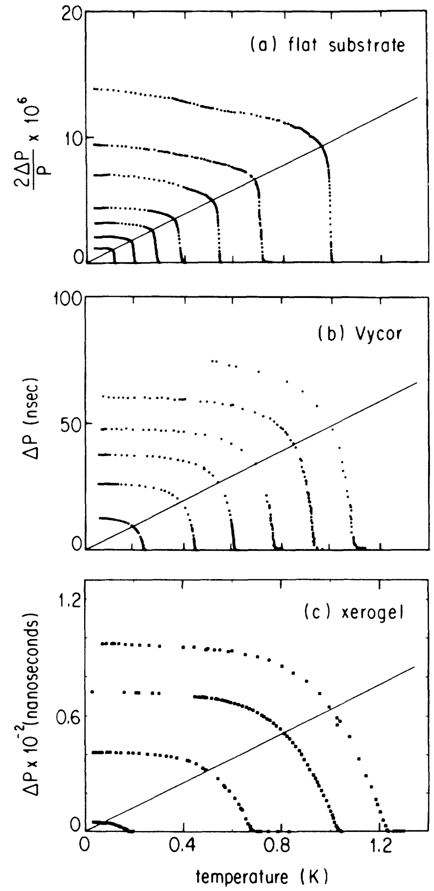

FIG. 1. Torsion oscillator data. (a) and (b) are reproduced from Ref. 3, and (c) is the data from Ref. 2.

Gary A. Williams
Physics Department
University of California
Los Angeles, California 90024

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[1] M. H. W. Chan *et al.*, Phys. Rev. Lett. **61**, 1950 (1988).
[2] K. Blum *et al.*, Jpn. J. Appl. Phys. **26**, Suppl. 26-3, 275 (1987).
[3] V. Kotsubo *et al.*, Phys. Rev. B **33**, 6106 (1986).
[4] F. Gallet *et al.*, Phys. Rev. B **39**, 4673 (1989); J. Machta *et al.*, Phys. Rev. Lett. **60**, 2054 (1988); T. Minoguchi *et al.*, Prog. Theor. Phys. **80**, 397 (1988).
[5] K. Blum, Ph.D. thesis, Cornell University, 1989 (unpublished).
[6] High-coverage curves were omitted from Figs. 1(b) and 1(c) due to capillary-condensation problems (Refs. 3 and 5).
[7] E. Courtens *et al.*, Proc. Roy. Soc. London A **423**, 55 (1989).
[8] Y. Gefen *et al.*, J. Phys. A **17**, 1277 (1984).
[9] J. Machta *et al.*, in *Quantum Fluids and Solids—1989,* edited by G. Ihas and Y. Takano (American Institute of Physics, New York, 1989), p. 161.