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Origin of Nonuniversality in Micellar Solutions: Comment

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Comment On "Origin of Nonuniversality in Micellar Solutions"

Shnidman[1] has proposed a mechanism for the apparent nonuniversality observed[2] in the critical behaviors of different aqueous solutions of nonionic amphiphiles. We argue that this mechanism is unrealistic and thus cannot be inducing the observed nonuniversality.

Shnidman suggests that a coarse-grained Hamiltonian describing such systems is

$$-\frac{\mathscr{H}}{k_B T} \equiv \sum_{\langle ij \rangle} \sigma_i \sigma_j + H \sum_i \sigma_i + \frac{H_0}{8} \sum (\sigma_i \sigma_j + \sigma_i + \sigma_j + 1), \quad (1)$$

where H is proportional to the difference in chemical potentials between the amphiphile and water, H_0 is a microscopic parameter,[1] and $\sigma = +1, -1$ corresponds to amphiphiles, water. The last term in Eq. (1) was not explicitly written down in Ref. 1, but it follows from Schnidman's description.

If the last interaction in Eq. (1) is short ranged, then we expect critical behavior in the Ising universality class. For instance, if the summation in Eq. (1) is over nearest-neighbor sites then this is an isotropic Ising model with shifted values for the exchange parameter $K + H_0/8$ and the magnetic field $H + zH_0/8$, where z is the lattice coordination number. As another example, if we assume the micelles to lie along a fixed direction, say x, then this is an anisotropic Ising model with two exchange parameters $K_x \equiv K + H_0/8$ and $K_y \equiv K_z \equiv K$, in a magnetic field $H + H_0/4$. A coexistence surface occurs for $H = -H_0/4$ which terminates at a line of Ising critical points. For a square lattice this line is $(e^{2K} - 1)(e^{2K + H_0/4} - 1) = 2$. Finally, if the H_0 term is short ranged, Shnidman's calculation scheme becomes universal because the only critical fixed point is the (unique) Ising critical fixed point. Therefore no genuine nonuniversality is produced by this mechanism.

The continuous variation of critical exponents obtained by Shnidman[1] is the artifact of *his* modification of the Migdal-Kadanoff position-space renormalization-group scheme which is exact for the hierarchical lattice of Fig. 1(a) (if $d = 2$). The noniterated bonds [dashed in Fig. 1(a)] corresponding to the H_0 interaction are responsible[3] for the nonuniversality. The range of the interaction is essentially infinite (see Fig. 1). However, any reasonable interaction must surely decay with increasing separation, and the Ising critical behavior is recovered, as argued before.

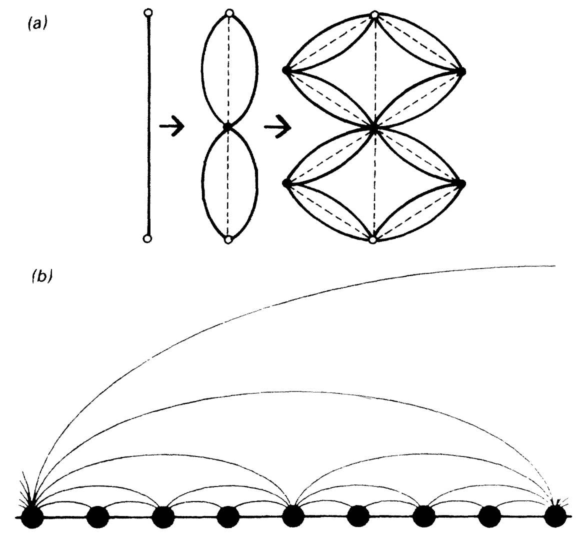

FIG. 1. (a) The first three iteration steps in the construction of the hierarchical lattice corresponding to $d = 2$. All the dashed bonds have the same strength H_0. On the infinite lattice, sites which are infinitely far apart are connected by bonds of finite strength. (b) The hierarchical lattice corresponding to Shnidman's calculation scheme for one dimension.

Shnidman's argument for the length independence of H_0 is not physically plausible.

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