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Origin of Nonuniversality in Micellar Solutions: Comment

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Comment On “Origin of Nonuniversality in Micellar Solutions”

Shnidman has proposed a mechanism for the apparent nonuniversality observed 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

\[ \frac{H}{k_B T} = \sum_{\langle i, j \rangle} \sigma_i \sigma_j + H \sum_i \sigma_i + \frac{H_0}{8} \sum (\sigma_i \sigma_j + \sigma_i + \sigma_j + 1), \]  

where \( H \) is proportional to the difference in chemical potentials between the amphiphile and water, \( H_0 \) is a microscopic parameter, 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 Shnidman’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 \( K_x = K + H_0/8 \) and \( K_y = K \), 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 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 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.

Shnidman’s argument for the length independence of \( H_0 \) is not physically plausible.

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