Comment on "Dynamic and Static Properties of the Randomly Pinned Flux Array"

In a recent Letter Batrouni and Hwa [1] reported results of numerical simulations of the planar flux array described by the random phase model

$$H = \frac{\kappa}{2} \sum_{\langle ij \rangle} (u_i - u_j)^2 - \lambda \sum_i \cos(2\pi u_i - \beta_i), \quad (1)$$

where $\langle ij \rangle$ denote nearest neighbor sites on a square lattice, u_i a real-valued displacementlike field, β_i a random phase uniformly distributed in the interval $[0, 2\pi]$, and λ the strength of the pinning potential. The main conclusion of the investigation in [1] was (a) that the various renormalization group (RG) predictions existing up to that time could be ruled out by their numerical results, which I agree with, and (b) that the disorder averaged correlation function $C(r) = [\langle (u_i - u_{i+r})^2 \rangle]_{\text{av}}$, where $\langle \cdots \rangle$ means the thermodynamic expectation value and $[\cdots]_{\text{av}}$ the disorder average, is indistinguishable from the pure case, i.e., $C(r) = C_{\lambda=0}(r) = T/\kappa\pi \log r$ for $T \le T_g = \kappa/\pi$.

In this Comment I would like to point out that the last statement is incorrect in general and only a consequence of the weakness of the disorder they used, namely $\lambda = 0.15$, and that for stronger disorder (or larger length scales) the correlation function $C(r)$ differs significantly from the pure case. Furthermore, the numerical data I obtain are compatible with the analytic predictions of [2,3] and the recent numerical results of a related model [4] with infinite disorder.

I used the usual Monte Carlo algorithm to calculate the static expectation values of the model (1) with $\kappa = 2$, implying $T_g \approx 0.637$. The system sizes were $L = 32$ and 64, where 1280 and 256 samples were used, respectively.

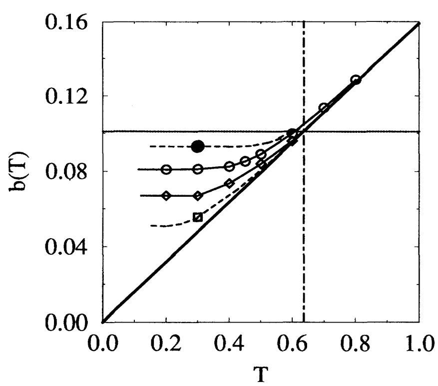

FIG. 1. The slope $b(T)$, obtained via a least squares fit of the MC data for $r \le L/4$, as a function of the temperature T. From top to bottom one has $\lambda = 2.0$ (●), 1.0 (○), 0.5 (◇), and 0.25 (□). Data for $\lambda = 0.15$ as obtained by Batrouni and Hwa [1] fall onto the thick full line $b(T) = T/\kappa\pi$, representing the pure model. The dash-dotted line indicates the glass transition temperature $T_g = \kappa/\pi$, and the dotted line is at $b(T) = T_g/\kappa\pi$. The statistical error is smaller than the size of the points; the systematic error is expected to be larger.

By applying a least squares fit of the data points for $C(r)$ with $r \le L/4$ [where the effect of the periodic boundary conditions, $C(r) = C(L - r)$ for $r \le L/2$ in the x and y directions, is still negligible] to the function $C(r) = a + b(T) \log r$ one gets the results shown in Fig. 1.

For weak disorder $\lambda \sim 0.15$ the slope $b(T)$ is indeed indistinguishable from the pure case $b(T) = T/\kappa\pi$, as Batrouni and Hwa observed [1]. However, by increasing the disorder ($\lambda \ge 0.5$) one obtains a slope $b(T)$ that is significantly different from the pure case already in the vicinity of T_g. Since systems with larger disorder are hard to equilibrate, only data for $\lambda \le 2$ are shown, but the trend seems to be obvious: the estimate of $b(T)$ obtained from intermediate length scales increases with increasing disorder strength. Furthermore, for some parameter sets (e.g., $\lambda = 0.5$, $T = 0.4$) one observes that the local slope $b(T, r) = \partial C(r)/\partial \log r$ is monotonically increasing for distances smaller than $L/4$, which indicates that the data shown in Fig. 1 are *lower bounds* for the asymptotic slope $b(T)$. Hence the results for the correlation function are compatible with $b(T) = T_g/\kappa\pi$ for $T \le T_g$, however; also a quadratic dependency $C(r) \sim \log^2 r$, implying $\lim_{r\to\infty} b(T, r) = \infty$, cannot be strictly excluded.

Concluding, I have presented numerical evidence that the disorder averaged spatial correlation function of model (1) is indeed distinct from the pure case $\lambda = 0$, which is in contrast to the findings of [1]. For weak disorder this becomes manifest only on length scales that are not attainable via Monte Carlo simulations yet, which is the reason why it was not detected in [1]. However, my results agree with the conclusions of [1] that the various RG predictions, prior to their work, were incorrect.

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