Comment on “Critical Dynamics of a Vortex-Loop Model for the Superconducting Transition”

In a recent Letter [1], Aji and Goldenfeld (AG) study the critical dynamics of the normal- to superconducting phase transition in zero magnetic field. They study both continuum models of vortex loops and discrete lattice models, often used in numerical simulations, and come to the surprising conclusion that their dynamic critical behavior differ. In this Comment we point out a serious problem in their analysis of the lattice models.

The critical behavior of type-II superconductors can be characterized by large scale fluctuations of vortex loops. Close to the phase transition, it is reasonable to assume overdamped relaxational dynamics for the vortex degrees of freedom, such as generated by a Monte Carlo (MC) simulation. Simulation studies of lattice models have shown that the resulting dynamic critical exponent $z$ is given by $z \approx 1.5$ for unscreened vortex interactions and $z \approx 2.7$ if the vortex interaction is assumed to be strongly screened [2, 3]. In high temperature superconductors, where critical fluctuations are most pronounced, the screening length is very large but finite. Under renormalization the screening length shrinks and hence both these limits are interesting to consider. The values of the critical exponents are surprising since the naive expectation from relaxational (Model-A) dynamics is an exponent close to $z \approx 2$ [4].

In their Letter, AG propose an explanation for the simulation results, but also argue that the lattice models do not capture the true continuum behavior which should instead have a dynamic exponent $z \approx 2$. They claim that the discrepancy is due to an incorrect identification of Monte Carlo time with real time. If true, this could lead to the predictions $\rho_s \sim L^{2x-d-2}$, $\mu \sim L^{d-2x}$, which are not supported by MC data.

In conclusion, the explanation of the simulation results offered by AG is not acceptable, since it is based on incorrect assumptions. There is no need for a scale-dependent correction in the proportionality between real time and MC time, and hence no correction to the dynamic exponents found in simulations. It remains to explain why these values are so far from the naive expectation.

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[1] Vivek Aji and Nigel Goldenfeld, Phys. Rev. Lett. 87, 197003 (2001).
[2] H. Weber and H. J. Jensen, Phys. Rev. Lett. 78, 2620 (1997).
[3] Jack Lidmar, Mats Wallin, Carsten Wengel, S. M. Girvin, and A. P. Young, Phys. Rev. B 58, 2827 (1998).
[4] P. C. Hohenberg and B. I. Halperin, Rev. Mod. Phys. 49, 435 (1977).
[5] Jack Lidmar and Mats Wallin, Europhys. Lett. 47, 494 (1999).