Field theoretical method for critical dynamics in thin films

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Critical dynamics in systems described by $O(n)$ symmetrical φ^4 Hamiltonian confined to a film geometry of finite lateral thickness L are considered at and above their bulk critical temperature T_c. Recently [1,2] it was shown, that for boundary conditions with zero modes, the zero mode present in Landau theory at T_c makes conventional renormalization–group–improved perturbation theory in $4-\varepsilon$ dimensions ill defined. This has been cured by reorganizing the field theory such that the ε expansion behaves well at T_c. This approach has been applied to calculate the scaling properties of fluctuation–induced forces at and above T_c. Here we extend this method to investigate critical dynamics in slabs with field theories involving zero mode. We propose a way to investigate the scaling properties of dynamic quantities in a systematic and controlled fashion. We apply the method for the computation of the scaling function of the dynamic susceptibility to one loop order in the case of periodic boundary conditions. In the limit $L/\xi_\infty \to 0$ (ξ_∞ – bulk correlation length) we obtain an $\varepsilon^{3/2}$ contribution besides the lowest ε term. In the opposite limit, $L/\xi_\infty \gg 1$, we find that the bulk dynamic susceptibility is approached exponentially as function of L/ξ_∞.

[1] H. W. Diehl, D. Grüneberg, and M. A. Shpot, Europhys. Lett. 75, 241 (2006).
[2] D. Grüneberg and H. W. Diehl, Phys. Rev. B 77, 115409 (2008).