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On spinodal points and Lee-Yang edge singularities

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The experimental signatures of the QCD critical point rely on the universal singular behavior of the equation of state at the critical point. Therefore, we study singularities of the universal scaling equation of state of the phi4 theory, or the Ising model. We focus on
the relation between spinodal points that limit the domain of metastability for temperatures below the critical temperature, i.e., T<Tc, and Lee-Yang edge singularities that limit the domain of analyticity around the point of zero magnetic field H for T>Tc. The extended analyticity conjecture (due to Fonseca and Zamolodchikov) that for T<Tc the Lee-Yang edge singularities are the closest singularities to the real H axis have interesting implications, in particular, that the spinodal singularities do not lie on the real H axis. We find that the Ising model parametric equation of state obtained in the epsilon=4-d expansion, as well as the related O(N) model equation of state at large N, are both non-trivially consistent with this conjecture, and analyze the reason for the difficulty of addressing this question using the epsilon-expansion. In particular, we resolve the long-standing paradox associated with the fact that the vicinity of the Lee-Yang edge singularity is described by Fisher's phi3 theory, which is non-perturbative even for d>=4 where the equation of state of the phi4 theory is expected to become mean-field-like. We derive the Ginzburg criterion that determines the size of the region around the Lee-Yang edge singularity, where the mean-field theory no longer applies.

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