Exact results for quenched disorder at criticality

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Quenched disorder plays a particularly interesting role within the theory of critical phenomena. The Harris criterion says that when the specific heat critical exponent of the pure model is positive, weak disorder drives the system towards a new (random) fixed point. Perturbation theory can be used to study these new fixed points but can hardly establish whether they possess qualitative features distinguishing them from those of pure systems. Looking for non-perturbative methods, attention turns to the two-dimensional case, in which conformal field theory has provided an exact and essentially complete characterization of universality classes of critical behavior for pure systems. It is a fact, however, that no conformal field theory for two-dimensional systems with quenched disorder has been identified. The two-dimensional random bond q-state Potts ferromagnet allows for random criticality for $q > 2$ and has played a central role in the study of quenched disorder. While Monte Carlo simulations by Chen et al and a simplified interfacial model by Kardar et al found evidence of q-independent critical exponents, a numerical transfer matrix study by Cardy and Jacobsen first found a q-dependent magnetization exponent consistent with the perturbative results of Ludwig and Dotsenko et al. The solution suggested for this puzzle, namely that different conclusions may refer to two critical lines with different disorder strength, found no alternative in the last twenty years.

We recently showed that an exact replica method can be introduced for the study of renormalization group fixed points of two-dimensional systems with quenched disorder. For the q-state Potts model we found that all the above mentioned results actually correspond to the same critical line, for which the disorder strength grows from weak to strong as q grows from 2 to infinity. Remarkably, this critical line possesses a symmetry-independent sector, and allows at the same time for a q-independent correlation length exponent and a varying magnetization exponent. These surprising features shed light on the peculiarities which may characterize random fixed points and open a new perspective for their study.

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[2] G. Delfino, Ann. Phys. **360**, 477 (2015).

[3] G. Delfino, Ann. Phys. **333**, 1 (2013).