Weak universality in spin models and lattice gauge theories

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Long-distance properties at a critical point separating an ordered and a disorderd phase are often fixed by the nature of the order parameter and the dimensionality of the system. An exception is provided by theories with marginal operators where critical exponents depend on microscopic details, in contrast to universal exponents at usual critical points. We discuss two such cases of *weak universality*. In the first example, we study a 1d spin-1/2 model with three-spin interactions and a transverse magnetic field h. The model is known to have a $Z_2 \times Z_2$ symmetry, and a duality between h and $1/h$. We present evidence that the self-dual point at $h = 1$ is a quantum critical point with a continuous phase transition that belongs to the four-state Potts model [Udupa, Sur, Nandy, Sen, Sen, to be published]. In the next example, we extend the classic Svetitsky-Yaffe scenario [Svetitsky, Yaffe, Nucl. Phys. B **210**, 423 (1982)] for deconfinement transitions in lattice gauge theories (LGTs) by adding higher charged matter fields ($Q = \pm 2$) to a $U(1)$ quantum link LGT in the spin $S = 1/2$ representation and show that the notion of universality is generalized such that the critical exponents γ, ν can change continuously as a coupling is varied, while their ratio is fixed to the 2-d Ising value. While such weak universality is well-known for spin models, we demonstrate this for LGTs for the first time using an efficient cluster algorithm [Sau, Sen, Banerjee, Phys. Rev. Lett. **130**, 071901 (2023)].