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The NPRG derivative expansion of O(N) models: conformal symmetry constraints and the principle of minimum sensitivity

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It is well known that the symmetries of a theory often restrict its form, and sometimes allow to totally determine it. In particular, it has been long conjectured that the O(N) models'critical regime is characterized by the presence of the complete conformal symmetry. Moreover, it has been proven for the specific values of N=1, 2, 3 and 4, that this is in fact the case. There exist numerous physical systems falling into O(N) universality classes for different values of N: pure substances and uniaxial magnets for N=1, ⍰-transition of liquid Helium-4 and planar magnets for N=2 or isotropic magnets for N=3, to mention but a few. Within the derivative expansion of the non-perturbative renormalization group for the O(N) models, special-conformal symmetry provides extra constraints which make the theory overdetermined and are, thus, not exactly fulfilled once the approximation is performed. In this study we extend previous works on the Ising universality class in which the non-physical parameters of the approximation –those that characterize the regulating function – are fixed by minimizing the breaking of the special conformal restrictions coming from the Ward-Takahashi identities for the vertices. We refer to this criterion as the Principle of Maximum Conformality (PMC). In this work, we numerically study this breaking for both the relevant perturbation of the fixed point, identified with the critical exponent ν, as well as for the least irrelevant perturbation, connected with the first correction to the long-distance scaling –the critical exponent, ω. Our results show that special conformal symmetry does indeed seem to be fulfilled in the critical regime of O(N) models, including examples without a clear unitary realization (N=0 and N=-2). More interestingly, we obtain results equivalent, for all practical purposes, to those coming from the Principle of Minimum Sensitivity (PMS). Considering this, we conclude that the PMS does not only reduce the spurious dependence on non-physical parameters, but also minimizes the breaking of the symmetries of the theory. Although the convergence properties of the DE are still to be completely understood, it was recently observed the existence of a parameter of order ¼ which regulates the convergence between successive orders. Additionally, from numerical results, it appears that the PMS criterion provides the estimations which converge fastest. Following this line, our present work suggests that seeking the best satisfaction of the conformal symmetry does in turn make the method converge faster –as the PMC and PMS criteria seem to be equivalent for the studied O(N) model cases.

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