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How partition function zeros help find out the finite-size scaling above the upper critical dimension

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For many years the question of finite-size scaling above the upper critical dimension dc was a source of many new theoretical results as well as new and interesting works in computer simulations, see [1] for a review . While in the thermodynamic limit system's scaling behaviour is mean-field, for the finitesize systems two scaling regimes are being considered. Simple approach is a trivial renormalization group fixed point, obtained by setting all fields to zero, called Gaussian fixed point, or G-scaling. Second scaling regime introduces a new scaling exponent $q = max(1, d/d_c)$, that governs the scaling of correlation length ξ with system size L, it is called Q-scaling. The latter was confirmed for periodic boundary conditions, both at the infinite system's critical temperature and at the pseudocritical points. For lattices with free boundary conditions the shifting and rounding of the susceptibility peak that occurs at the pseudocritical point are big enough to position the pseudocriticality far from the critical point of the infinite system. This leads to both scaling regimes emerge, so theory predicted G-scaling at T_c and Q-scaling at T_L. Numerical validation of the finite-size scaling for free boundary conditions was not clear, as the boundary effects are too strong to observe the scaling picture accurately. In this work we show the shortcomings of the regular computer simulations methods and improve the quality of the finite-size scaling using the Lee-Yang zeros technique. Using the partition function zeros provides us with the more accurate scaling picture with smaller lattice sizes at hand [2].

1. Berche, B.; Ellis, T.; Holovatch, Yu.; Kenna, R. Phase Transitions above the Upper Critical Dimension. SciPost Phys. Lect. Notes 2022, 60. DOI: 10.21468/SciPostPhysLectNotes.60
2. Honchar Yu., Berche B., Holovatch Yu., Kenna R. When correlations exceed system size: finite-size scaling in free boundary conditions above the upper critical dimension. // preprint ArXiv:. - 2023. - arXiv:2311.11721. (to appear in Condens.Matter Phys 2024, 1) DOI:10.48550/arXiv.2311.11721

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