Contribution ID: **99** Type: **not specified**

Generalization of the Central Limit Theorem to critical systems: A Perturbative Approach

Tuesday 24 September 2024 14:30 (1h 40m)

The Central Limit Theorem does not hold for strongly correlated stochastic variables, as is the case for statistical systems close to criticality. Recently, the calculation of the probability distribution function (PDF) of the magnetization mode has been performed with the functional renormalization group (FRG) in the case of the three dimensional Ising model . We show how this PDF or, equivalently, the rate function which is its logarithm, can be systematically computed perturbatively in the $\epsilon = 4 - d$ expansion. At the price of making an RG improvement functionally, we find that our results compare very well with the FRG calculations and Monte Carlo simulations even for the tail of the distribution, that is, at large magnetization. This holds true for the entire family of universal PDFs parameterized by $\zeta = \lim_{L,\xi_\infty \to \infty} L/\xi_\infty$ which is the ratio of the system size L to the correlation length ξ_∞ with both the thermodynamic limit and the critical limit being taken simultaneously.

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Session Classification: Poster Session