Critical behavior and continuum scaling of 3D $Z(N)$ lattice gauge theories

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Introduction

$Z(N)$ lattice gauge theories (LGTs), at $T = 0$ and $T > 0$, are interesting on their own and can provide useful insights into the universal properties of 3D (N) LGTs, being $Z(N)$ the center subgroup of $SU(N)$.

The most general action for the $Z(N)$ LGT is

$$S = \sum_{\Box} \sum_{n=1}^{N} \sum_{k} \sum_{i} \frac{2\pi}{N} \cos \left( \frac{2\pi}{N} s_i(x + e_k) + \beta s_i(x) \right),$$

with fields defined on links, $s_i(x) = 1, \ldots, N - 1$.

Potts models: all $\beta_i$ equal; Vector model: otherwise;

Conventional vector model: $\beta_1 > 0$, $\beta_2 < 0$, $\cdots$, $\beta_{N-1} > 0$.

Duality transformation

### General 3D $Z(N)$ gauge theory on an anisotropic lattice:

$$Z(2|\beta_1, \beta_2) = \prod_{\Box} \prod_{k} \prod_{i} \frac{Q(s_i(x))}{\prod_{j} Q(s_i(x))}.$$

### Critical indices at the two transitions

The scaling laws at the critical points, $M_{\nu} = \mathbf{A}^{\nu}/N^c$, are used to extract $\beta(1)/\nu = 2 - \beta(2)/\nu$ at the two transitions.

The reference value for $\beta(2)$ is 1/4.

Conclusions

- All 3D vector $Z(N = 4)$ LGTs at $T > 0$ considered in Ref. [10] and in the present study feature two BKT-like phase transitions.
- Critical indices suggest that these models belong to the universality class of 2D ($Z(N)$) vector spin models, in agreement with the Swiecki-Yaffe conjecture.
- We proposed and checked a formula for the scaling with $N$ of the critical coupling of the second phase transition.
- Using the value of the index $\nu$ obtained by us at $T = 0$, we checked the continuum scaling and predicted an approximate value for $T_c$ in the continuum limit.

Acknowledgments

This work was partially supported by the INFN SUMA project.

References