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Z_N symmetry in $SU(N)$ gauge theories

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Abstract: We study Z_N symmetry in $SU(N)$ gauge theories in the presence of matter fields in the fundamental representation. To understand the Z_N symmetry explicit breaking analytically we have considered a simple temporal one dimensional model which results from considering fields which are uniform in the spatial directions and the gauge fields with vanishing spatial components. To derive the free energy corresponding to the Polyakov loop, the partition function is evaluated for a given background of temporal gauge links where all the gauge links in the temporal direction are set to unity except the last link. The matter fields are then integrated out sequentially except for the two fields which are connected to the last link. We show that in the limit of large number of temporal sites the resulting free energy is independent of the Z_N explicit breaking term i.e the explicit breaking of Z_N symmetry vanishes, driven by dominance of the density of states. The present calculations leave out the effect of the spatial links and non-zero spatial modes of the matter fields. These modes are responsible for the Higgs and the chiral transitions, which are entropy driven. We argue that the spatial links as well as the spatial modes of the matter fields determine the boundaries separating regions where Z_N symmetry is realised from the rest.

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