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SU(2) Lattice Gauge Theory: Standard Action Versus Symanzik's Tree-Improved Action

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Dedicated to the memory of Kurt Symanzik

Abstract. We carry out Monte Carlo simulations of the $4d$ SU(2) lattice gauge theory. The standard action and the Symanzik tree-improved action are used. Results for the string tension, glueball masses, and energy-momentum dispersion are reported. In case of the standard action our results are a finite size study extending previous investigations.

I. Introduction

Symanzik [1, 2] has pointed out that corrections to continuum theory stemming from finite lattice spacing can be systematically diminished by use of a judiciously chosen lattice action. A number of Monte Carlo (MC) studies [3] have been carried out using Symanzik improved action. In this paper we report high statistics results for $4d$ SU(2) lattice gauge theory.

In the continuum limit each physical quantity is proportional to an appropriate power of the correlation length (inverse mass gap) ξ with an universal coefficient. For non-zero lattice spacing $a \neq 0$ this "scaling" is violated by non-universal terms of order $(a^2/\xi^2)\ln(a/\xi)$. Symanzik improved actions allow us to reduce these violations to order $(a^2/\xi^2)^2 \ln(a/\xi)$, to all orders of perturbation theory, by including in the lattice action suitable chosen irrelevant terms.

In principle the coefficients of these irrelevant terms can be calculated up to any given order of perturbation theory. For $4d$ SU(n) lattice gauge theories the tree-level improved action (TIA) has been determined [4–6]. A motivated ansatz [5] for the improved action includes Wilson loops up to length 6 and the result

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