Distinguishability of some ununified models

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We calculate the left-right asymmetry parameters A^-, B^-, and $C^-_{L,R}$ in the polarized e–d and e–p deep-inelastic scattering processes for two recently proposed ununified models, in which the quarks and leptons transform nontrivially under different electroweak gauge groups. We then compare the various asymmetry parameters in these ununified models with those of the standard electroweak model. None of the ununified models can be discriminated from the standard model through measurements of the parameters A^-, B^-, and C^-_L. Both of these models are markedly distinguishable through measurement of C^-_R, which is particularly sensitive in the range $0.3 \leq y \leq 0.5$.

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I. INTRODUCTION

The remarkable success of the standard electroweak model at low energies has encouraged formulation of viable alternative theories with expanded gauge groups [1] and motivated measurements of parameters [2] which can discriminate these theories from the standard model. Cahn and Gilman [3] have shown that some of the extensions of the standard model can be distinguished through measurements of asymmetry parameters in the deep-inelastic scattering of polarized electrons by unpolarized protons at $Q^2 = 1\ \mathrm{GeV}^2/c^2$. It is this point of view which has motivated us to calculate the asymmetry parameters in two recently proposed models [4, 5] in order to establish their distinguishability from the standard model.

Recently Georgi, Jenkins, and Simmons [4] have proposed an extension of the standard model (hereafter referred to as the partially ununified model) based on the gauge group $\mathrm{SU}(2)_q \otimes \mathrm{SU}(2)_l \otimes \mathrm{U}(1)_Y$ which partially ununifies the standard model in the sense that the left-handed quarks and leptons couple to different SU(2) gauge groups and right-handed fermions transform as singlets under both. Several authors [6–8] have undertaken some phenomenological studies such as the hadronic decays of W's and Z's, forward-backward asymmetries in $e^+e^- \longrightarrow \mu^+\mu^-, b\bar{b}$ processes, B^0-$\bar{B}0$ mixing and the decay widths $\Gamma(Z \longrightarrow l^+l^-)$ and $\Gamma(Z \longrightarrow \text{hadrons})$ in the context of this partially ununified model and obtained some constraints for the model parameters.

Another fully ununified electroweak model [5] has also been recently proposed which ununifies completely the quarks and the leptons based on the group $G_{qL} \otimes G_{lL}$ where $G_{qL} = \mathrm{SU}(2)_{qL} \otimes \mathrm{U}(1)_{Yq}$ and $G_{lL} = \mathrm{SU}(2)_{lL} \otimes \mathrm{U}(1)_{Yl}$. The quarks (leptons) transform under G_{qL} (G_{lL}) exactly as they do under the standard electroweak model. In this model the charged-gauge-boson sector remains the same as in the partially ununified model, but the neutral-gauge-boson sector has been enlarged due to the inclusion of another Z, of course, the lightest of which is the one corresponding to the standard model.

The ununified models were originally proposed as yet another possible extension of the standard model. But afterwards it was found that in some grand unified theories such as SU(15) or SU(16), where baryon number is a gauge symmetry, one can embed the ununified models naturally. In these theories it is possible to suppress proton decay and one can have unification at low energies. These theories require ununified models to be present at the TeV scale [9]. Thus, observing a signature of the ununified model in various asymmetry experiments can imply low-energy grand unification and very rich and interesting new phenomenology in next-generation experiments.

In the present work we focus our attention on the mixing of weak neutral gauge bosons in the partially ununified and fully ununified model which leads to the deviations from the standard-model prediction in the weak-neutral-current sector and we propose to calculate the left-right asymmetry parameters $A^-, B^-, C^-_{L,R}$, in deep-inelastic e^--d and e^--p scattering in the context of both the models and compare them with the standard model.

Our analysis shows that none of the ununified models can be discriminated from the standard model through measurements of the parameters A^-, B^-, and C^-_L in the deep-inelastic e-d and e-p scattering processes. However, both the models can be distinguished from the standard model if the parameter B^- is measured for values of y in the range $0 \leq y \leq 0.1$. Interestingly the parameter C^-_R in e-d and e-p scattering will unambiguously discriminate the partially ununified as well as the fully ununified model from the standard electroweak model.

The structure of the paper is as follows. In Sec. II we describe the models and the new parameters entering in them. Section III contains our calculation of the various asymmetry parameters in these models. The results are presented in Sec. IV. We summarize our analysis in Sec. V.

