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Flipped left-right gauge model with τ-gaugino mixing

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Abstract

A supersymmetric left-right gauge model is considered, where the mixing between τ and the $SU(2)_R$ gaugino χ_R occurs due to a "flipped" assignment for the matter fields. The model parameters are restricted so that the τ-χ_R mass matrix reproduces the m_τ and the small left-handed τ-χ_R mixing angle. The τ-χ_R mixing effects are expected to be seen clearly in the gauge boson decays as the violation of lepton universality.

In this talk, I discuss some aspects of a new type of supersymmetric left-right gauge model.[1] (This is based on the investigations made in collaboration with N. Nishii and I. Umemura.[2]) The gauge symmetry of the model is

$$G = SU(3)_C \times SU(2)_L \times SU(2)_R \times U(1)_K. \qquad (1)$$

The matter superfields together with their G quantum numbers are given by

$$Q = (u,d) \sim (3,2,1,\tfrac{1}{6}), \quad d^c \sim (3^*,1,1,\tfrac{1}{3}),$$

$$D \sim (3,1,1,-\tfrac{1}{3}), \quad Q^c = (D^c,u^c) \sim (3^*,1,2,-\tfrac{1}{6}),$$

$$E^c = (e^c,N) \sim (1,1,2,\tfrac{1}{2}), \quad H = (H^0,H^-) \sim (1,2,1,-\tfrac{1}{2}),$$

$$\Delta = \begin{pmatrix} \nu & \bar{H}^+ \\ e & \bar{H}^0 \end{pmatrix} \sim (1,2,2,0), \quad N^c \sim (1,1,1,0), \qquad (2)$$

where the generation indices are omitted. The gauge symmetry is spontaneously broken,

$$G \rightarrow SU(3)_C \times U(1)_{EM}, \tag{3}$$

by the VEVs $\sim$ (100GeV $\sim$ 1TeV) of the third generation of the Higgs fields,[1,2]

$$\langle \bar{H}_3^0 \rangle \equiv v, \quad \langle H_3^0 \rangle \equiv v_L, \quad \langle N_3 \rangle \equiv v_R. \tag{4}$$

The weak-hypercharge and electric charge are then determined by

$$Y = I_R^3 + K, \quad Q_{EM} = I_L^3 + Y. \tag{5}$$

The superpotential has a form

$$W = \lambda_1 Q^c Q \Delta + \lambda_2 d^c Q H + \lambda_3 Q^c D E^c + \lambda_4 E^c \Delta H. \tag{6}$$

Then, some global symmetries appear,

$$U(1)_B \times U(1)_X , \tag{7}$$

where B denotes the baryon number and the X charges are assigned as

$$X(D, Q^c, E^c, \Delta, \text{others}) = (1, -\tfrac{1}{2}, -\tfrac{1}{2}, \tfrac{1}{2}, 0). \tag{8}$$

The global lepton number $U(1)_L$ remains unbroken after the gauge symmetry breaking (3), by combining the $SU(2)_R$ and $U(1)_X$:

$$L = X - I_R^3. \tag{9}$$

This realizes the "flipped" lepton number assignment for the matter multiplets (2) and the charged $SU(2)_R$ gauge fields with $L(W_R^{\pm}) = \mp 1$.

A remarkable feature of this model is that since the $SU(2)_R$ doublets accomodate both the lepton and Higgs superfields in accordance with the lepton number assignment (9), the charged leptons may mix with the gaugino χ_R of the $SU(2)_R$ through the VEVs to break the $SU(2)_R$.[2] By virtue of the generation symmetry[1,2] to restrict the flavor changing interactions, e and μ, however, evade the mixing with χ_R so as not to upset their well established phenomenological properties. Hence, only τ mixes with χ_R through the VEVs (4). We denote the left- and right-handed τ-χ_R mixing angles by ϕ_- and ϕ_+, respectively.

The current of τ coupled to the W_L boson is reduced by the left-handed τ-χ_R mixing:

$$J_L^\mu = \frac{1}{\sqrt{2}}\cos\phi_- \gamma^\mu \bar{\nu}_\tau \frac{1}{2}(1-\gamma_5)\tau. \tag{10}$$

At present, a mall nonzero value may be allowed for ϕ_-, i.e.,

$$\cos\phi_- = 1 - O(10^{-2}), \tag{11}$$

as suggested from the some what long lifetime of τ, while the ϕ_+ is rather elusive in low-energy phenomena.

Reasonable ranges of the model parameters such as $\phi_\pm$ and m_t are found by considering that the τ-χ_R mass matrix should reproduce $m_\tau \simeq 1.78$ GeV and small enough values for ϕ_- which are consistent with the observed τ decays. In this analysis, the perturbation condition on the Yukawa couplings at large scales is taken account. It is, in particular, found that ϕ_+ can be considerably large.

It is expected at high energies that the effects of τ-χ_R mixing are more clearly seen in the gauge boson decays into lepton pairs as the violation of lepton universality. $BR(Z \to \tau^+\tau^-)$, in particular, could be smaller than $BR(Z \to e^+e^-)$ by more than a few % if $\cos\phi_- \lesssim 0.995$, which will be checked soon at LEP. On the other hand, the effects of ϕ_+ will be drastic in the extra Z' decays; BR(Z'→ $\tau^+\tau^-$) is presumably larger than BR(Z'→ e^+e^-) by more than several tens %.

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