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The one loop corrections to the neutrino masses in BLMSSM

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Abstract

The neutrino masses and mixings are studied in the model which is the supersymmetric extension of the standard model with local gauged baryon and lepton numbers (BLMSSM). At tree level the neutrinos can obtain tiny masses through the See-Saw mechanism in the BLMSSM. The one-loop corrections to the neutrino masses and mixings are important, and they are studied in this work with the mass insertion approximation. We study the numerical results and discuss the allowed parameter space of BLMSSM. It can contribute to study the neutrino masses and to explore the new physics beyond the standard model (SM).

1. Introduction

When the CP-even Higgs h^0 with $m_{h^0} = 125.7$ GeV was detected by LHC in 2012 [1], all the particles in SM have been founded. Though SM obtains large successes, it is unable to explain some phenomena. For example, SM cannot explain the neutrino masses and their mixing pattern [2], because in SM there are only three left-handed neutrinos with zero mass. The anomalous neutrino data from both solar and atmospheric neutrino experiments promote the study of neutrino masses and lepton flavor violating processes. The authors give out the global analyses

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of neutrino oscillation experiments in their work, and the present 3σ limits for the neutrino experiment data are [3]

$$
\begin{aligned}
&0.0188 \leq \sin^2\theta_{13} \leq 0.0251,\\
&0.270 \leq \sin^2\theta_{12} \leq 0.344,\\
&0.385 \leq \sin^2\theta_{23} \leq 0.644,\\
&7.02\times10^{-5}\ \mathrm{eV}^2 \leq \Delta m^2_{\odot} \leq 8.09\times10^{-5}\ \mathrm{eV}^2,\\
&2.325\times10^{-3}\ \mathrm{eV}^2 \leq \Delta m^2_{A}(\mathtt{NO}) \leq 2.599\times10^{-3}\ \mathrm{eV}^2,\\
&-2.590\times10^{-3}\ \mathrm{eV}^2 \leq \Delta m^2_{A}(\mathtt{IO}) \leq -2.307\times10^{-3}\ \mathrm{eV}^2.
\end{aligned}
\tag{1}
$$

For the mixing pattern, there are two large mixing angles and one small mixing angle. To explain the results in Eq. (1), a theory beyond the SM is necessary. Therefore, the neutrino sector is a natural testing ground for the new models beyond the SM.

For the new physics, the supersymmetric extension of the SM is a popular choice. The discrete symmetry known as R-parity is defined as $R_p = (-1)^{L+3B+2S}$ with $L(B)$, S denoting the lepton (baryon) number and the spin of the particle [4]. The minimal supersymmetric extension of the SM (MSSM) [5] has been studied for many years by theoretical physicists. MSSM with R-parity conservation has some short comings, where neither μ problem nor the observed neutrino masses can be explained. R-parity violation can be obtained from L breaking, B breaking, both L and B breaking. In general, to explain the neutrino experiment data, the lepton number should be broken.

In R-parity violating supersymmetric models with generic soft supersymmetry breaking terms [6], neutrinos and neutralinos mix together at tree level. Therefore, one neutrino gets small mass through the see-saw mechanism [7]. The loop diagrams including lepton number violating effects provide masses to the other neutrinos. Taking into account the one loop effects, the authors research the neutrino masses and mixings. In $\mu\nu SSM$ three right-handed neutrino superfields are introduced [8,9], and it can solve the μ problem. In this model [10], the neutrino masses and mixings are studied at one loop level, and significative results are obtained.

The BLMSSM is the minimal supersymmetric extension of the SM with local gauged B and L, which is spontaneously broken at TeV scale [11]. This model was first proposed by the authors in Ref. [12]. So BLMSSM is R-parity violating and can explain the asymmetry of matter-antimatter in the universe. In BLMSSM, the authors study the lightest CP-even Higgs mass and the decays $h^0 \to \gamma\gamma$, $h^0 \to ZZ(WW)$ [13]. The one loop and two loop Barr-Zee type contributions to muon MDM and charged lepton flavor violating processes are also discussed [14]. Considering the CP-violation, we study neutron EDM, lepton EDM and $B^0 - \bar{B}^0$ mixing in this model [15].

In the BLMSSM, because of the introduced right-handed neutrino fields, the three light neutrinos obtain tiny masses at tree level through the see-saw mechanism, which is shown in our previous work [16]. Here, using the mass insertion approximation we consider one loop corrections to the neutrino mass mixing matrix. The one loop corrections are important, especially for the light neutrinos.

After this introduction, in Section 2 we briefly introduce the BLMSSM. With mass insertion method, the one loop corrections to neutrino mass matrix are shown in Section 3. Section 4 is devoted to the numerical analysis. The summary is given out in Section 5.