Introduction

Problems we can’t understand with SM

- Neutrino mass?
- Dark matter?
- Baryon number asymmetry?

- The radiative neutrino mass model with an inert doublet scalar can explain these problems if dark matter is identified with the lightest neutral component of the inert doublet.
- Recently, the new data of the neutrino oscillation such as a non-zero value of $\theta_{13}$ have been established by the reactor experiments.

Using the parameters which satisfy with these new data, we reexamine whether the baryon number asymmetry can be realized in this model.

2. The radiative neutrino mass model with an inert doublet scalar

Neutralino mass?

Recently, the new data of the neutrino oscillation such as a non-zero value of $\theta_{13}$ have been established by the reactor experiments.

We need examine the inverted hierarchy case.

Dark matter

We assume the neutral component $H_2$ of the inert doublet is the lightest of $Z_2$ odd particles.

$H_2$ decay is forbidden under $Z_2$ symmetry.

$N_1$ can be the dark matter candidate.

Baryon number asymmetry

Lepton flavor structure

To fix the flavor structure, we assume that

- $h_{1i} = 0$, $h_{2i} = h_i$, $h_{3i} = q_i h_i$, $i = 1, 2$;
- $h_{23} = h_3, h_{33} = -q_3 h_3, h_{23} = -q_3 h_3$

In case of $q_{1,2,3} = 1$, the neutrino mass matrix can be diagonalized by PMNS matrix

$\nu_{PMNS} = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos \theta & \sin \theta \\ 0 & -\sin \theta & \cos \theta \end{pmatrix}$

The results

$\sin^2 2\theta_{13} = 0.080$

$|\theta_1| > 3.50 \times 10^{-3}$

$|\theta_2| = 1.40 \times 10^{-3}$

The required relic abundance is realized for $|\lambda_3 + \lambda_l| = O(1)$.

Baryon number asymmetry

Baryon asymmetry can be realized through TeV scale leptogenesis.

The washout effects are too large to realize our universe.

To obtain enough baryon number, the washout processes should be suppressed.

Resonant leptogenesis

To suppress the washout processes, we make neutrino Yukawa couplings smaller.

- Too small neutrino masses $M_{\nu}=\sum_{i=1}^{3} h_{\mu} h_{\mu}^{\dagger} h_{i}$
- Too small CP asymmetry $\epsilon \propto \frac{m_0 \Delta m_{31}^{2}}{m_1 m_2}$

If we make $\lambda_3$ larger, we can recover neutrino masses.

We can obtain the required baryon asymmetry in the case of $\Delta \sim O(10^{10})$.

This is rather mild degeneracy compared with the ordinary case.

Summary

We reexamined the baryon number asymmetry in the radiative neutrino mass model with an inert doublet which can explain the DM relic abundance and the small neutrino masses.

Lepton number asymmetry is too small!!