Impact of One Zero Textures on Baryogenesis in A Flavor Symmetric Scotogenic Model

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***Abstract*—We have realized a discrete flavor symmetric scotogenic model in our work. As widely known, the scotogenic model is a significant model as it can accomodate small neutrino mass along with dark matter candidate. Phenomenologies such as baryogenesis and neutrinoless double beta decay can also be very well explained in this model with appropriate choice of parameters. Our work mainly focuses on obtaining one zero textures of the Yukawa coupling matrix from the flavor symmetric model. By consideration of different vev alignments, we get three different structures of one zero texture Yukawa coupling matrices from the model. Further, we analyse the impact of these structures on baryogenesis and compare their results with constraints from Planck data .**

Keywords*—Scotogenic model; neutrino mass; neutrinoless double beta decay

I. INTRODUCTION

As we know that the Standard model(SM) of particle physics is inadequate in explaining the smallness of neutrino mass, dark matter, baryon asymmetry of the Universe, we therefore need beyond Standard model frameworks. One such framework include the Scotogenic model which is an extension of the Standard model with the help of three neutral fermions and an inert scalar doublet[2]. The advantage of this model over other frameworks is that it can accommodate both neutrino mass and dark matter phenomenology simultaneously. In our work, we have realized the the scotogenic model with the help of discrete flavor symmetries. This helps us in generating three different one zero textures of Yukawa coupling matrix. However, we have analyzed the phenomena of only one texture zero Yukawa matrix and studied its impact on baryon asymmetry of the Universe.

II. SCOTOGENIC MODEL

Scotogenic model is a popular model which can accommodate neutrino mass and dark matter by minimally extending the Standard model. It was proposed by Ernest Ma[1]. This model comprises of three copies of neutral singlet fermion N_i(i=1,2,3) and one inert scalar doublet η in addition to the particle content of the Standard model. Here, the mass of the active neutrino is generated via one-loop mechanism(FIG1) unlike other seesaw mechanism where the neutrino mass is produced at tree level. Also an inbuilt symmetry Z_2 is also present in the model under which the SM particles are even and the newly added particles are odd. The transformation of the particles under the symmetry group $SU(3)\otimes SU(2)\otimes U(1)_Y$ along with the equations representing its potential and Lagrangian are explicitly discussed in the literature[1,3].

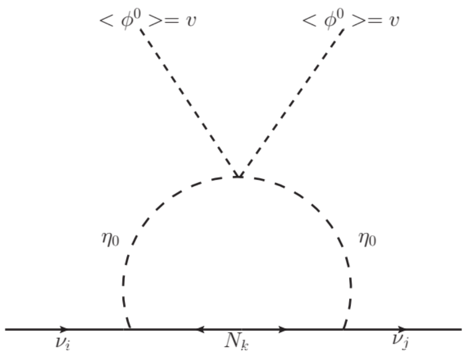

FIG1: ONE-LOOP MECHANISM OF GENERATING NEUTRINO MASS.

III. THE MODEL

In order to generate the required structures of the Yukawa coupling matrix, further incorporating which we will get the light neutrino mass matrix, we introduce flavor symmetry to our model. We have realized the scotogenic model with the help of discrete flavor symmetries $A_4 \otimes Z_4$. . With appropriate choice of vev alignments, we can have three one zero textures of Yukawa coupling matrix, however we study only one case in this work.

The Yukawa coupling matrix is given by:

$$Y=\begin{bmatrix} y_1 & y_2 & y_3 \\ y_1 & 0 & y_3 \\ y_1 & -y_2 & y_3 \end{bmatrix}$$

Considering this coupling matrix form, we carry out the phenomenology baryon asymmetry of the Universe and check its production.

IV. RESULTS AND ANALYSIS

For numerically solving the model parameters, we use a special type of parametrization known as Casas-Ibarra parametrization[5]. After generating the values of the model parameters and then using it in the Yukawa coupling matrix, we can use it for studying baryogenesis. For the baryon asymmetry of the Universe(BAU) to fall in the weak washout regime, we choose the mass hierarchy of the right handed neutrino mass as $M_1 << M_{2,3}$. Also the mass of the lightest inert Higgs doublet scalar is choosen in the range 450-750 GeV which is allowed from the cosmological aspect. Thus , by the choice of these parameters, we can get the observed baryon asymmetry obeying the Planck limit. We can produce

observed baryogenesis via the mechanism of leptogenesis in our model. However, the leptogenesis process must occur by the out of equilibrium decay of the RHN, in our case N_1 . As known from various work, there exists a lower bound of about 10TeV[4] for M_1 in the Scotogenic model considering the vanilla leptogenesis scenario.
From the plots in FIG2, we can see that the mass range of the RHN N_1 and that of the dark matter particles η satisfy the Planck limit for BAU for both NH/IH. This justifies the structure of the Yukawa coupling matrix, thus making the model viable from cosmological view point.

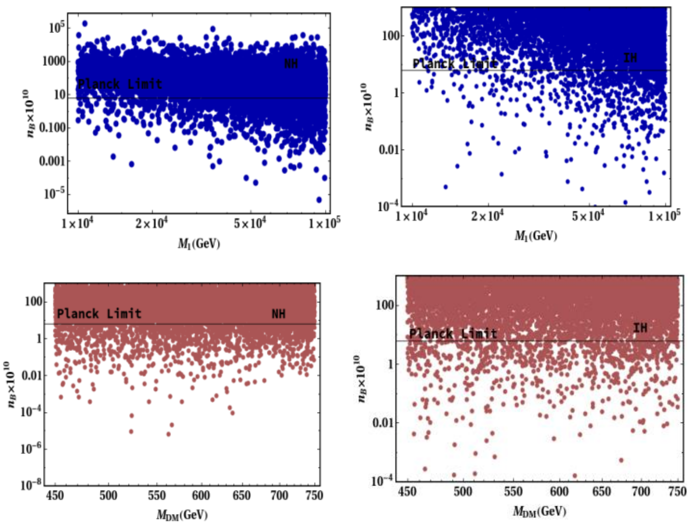

FIG2: The first row of the below plot depicts the variation of baryon asymmetry of the Universe as a function of lightest RHN mass M_1.The second row shows plot between baryon asymmetry of the Universe and dark matter mass M_{DM}. Both the plots are done for normal (NH) as well as inverted hierarchy(IH). The horizontal line is the Planck limit for BAU, i.e. $6.05*10^{-10}$.

V. CONCLUSION

We have basically realized the minimal scotogenic model with the help of discrete flavor symmetries in order to have a constraint in the Yukawa coupling matrix, thereby constraining the model. Also we have specifically produced a one zero texture Yukawa coupling matrix and studied its impact on BAU. As already mentioned in the results, we have obtained plots which showcase that the parameter space considered throughout our is consistent in successfully generating the observed BAU. For the mass range of RHN nad dark matter, we see that for both the heirarchies, the BAU falls in allowed limit given by Planck data. Thus, we can conclude that the model is viable and explains the inadequacy faced in the Standard Model.

VI. REFERENCES

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