A

Appendix

Derivation of the mass matrix term for light neutrinos in scotogenic model

Applying the Feynman rules to fig.(2.1), we have the following terms as :

N_k: fermionic propagator, η_R^0 and η_I^0: scalar propagator, momentum of fermionic propagator is given by k, that of ν_i is given by p and for scalar propagator momentum is denoted by p-k. Further, we get the Feynamn propagator for η_R^0 as: $\frac{i}{(p\text{-}k)^2-m^2_{\eta_R^0}}$ and the Feynman fermionic propagator as:$\frac{i(\not{k}+M_k)}{k^2-M_k^2}$. As it is a one loop diagram, we have only one undetermined loop momentum term given by $\frac{d^4k}{(2\pi)^4}$. Therefore, taking into account all the Feynman rules, we can write the integral of the form :

$$-i\sum_{ij}^{\nu} = -\int \frac{d^4k}{(2\pi)^4} h_{ik} \frac{i(\not{k}+M_k)}{k^2-M_k^2} h_{jk} \frac{i}{(p-k)^2-m^2_{\eta_R^0}}$$

$$= \int \frac{d^4k}{(2\pi)^4} h_{ik} \frac{i(\not{k} + M_k)}{k^2 - M_k^2} h_{jk} \frac{i}{(p-k)^2 - m^2_{\eta^0_R}} \tag{A.1}$$

In order to convert the tensorial integral to scalar form we drop off $\not{k}$ and set the momentum p to zero. Therefore, the resulting integral takes the form:

$$-i\sum_{ij}^{\nu} = \int \frac{d^4k}{(2\pi)^4} h_{ik} h_{jk} \frac{M_k}{(k^2 - M_k^2)(k^2 - m^2_{\eta^0_R})} \tag{A.2}$$

As from the integral, we can see that it is logarithmically divergent, however this divergence is not a physical one for it was artificially introduced after EWSB with our splitting of the diagram. Thus, we will obtain a finite mass because the infinities in the two integrals will be the same and thereby cancelled out. Expressing the above integral in terms of a *Passarino-Veltman* function, we have:

$$I_{\eta^0_R} = h_{ik} h_{jk} M_k \frac{i}{16\pi^2} B_0(p^2 = 0, M_k^2, m^2_{\eta^0_R}). \tag{A.3}$$

We will again have a similar equation for the imaginary part of the diagram given by:

$$I_{\eta^0_I} = h_{ik} h_{jk} M_k \frac{i}{16\pi^2} B_0(p^2 = 0, M_k^2, m^2_{\eta^0_I}). \tag{A.4}$$

The analytical expression for the *Passarino-Veltman* function B_0 is of the form:

$$B_0(0, M_k^2, m^2_{\eta^0_R}) = \Delta - \int_0^1 dx\, ln \frac{x(M_k^2 - m^2_{\eta^0_R})}{\mu^2} + \frac{m^2_{\eta^0_R}}{\mu^2} \tag{A.5}$$

With the help of the integration :

$$\int ln(Ax + B) = \frac{1}{A}(Ax + B)\, ln(Ax + B) - x, \tag{A.6}$$

we arrive at the final expressions for B_0 for real and imaginary parts which looks like:

$$B_0(0, M_k^2, m^2_{\eta^0_R}) = \frac{2}{\varepsilon} + 1 - ln\frac{M_k^2}{\mu^2} + \frac{m^2_{\eta^0_R}}{M_k^2 - m^2_{\eta^0_R}}\, ln\frac{m^2_{\eta^0_R}}{M_k^2}. \tag{A.7}$$

$$B_0(0,M_k^2,m_{\eta_I^0}^2)=\frac{2}{\varepsilon}+1-ln\frac{M_k^2}{\mu^2}+\frac{m_{\eta_I^0}^2}{M_k^2-m_{\eta_I^0}^2}ln\frac{m_{\eta_I^0}^2}{M_k^2}. \tag{A.8}$$

Now, replacing the values of B_0 in eqs.(A.3)&(A.4), we get:

$$I_{\eta_R^0}=\frac{h_{ik}h_{jk}M_k i}{16\pi^2}\{\frac{2}{\varepsilon}+1-ln\frac{M_k^2}{\mu^2}+\frac{m_{\eta_R^0}^2}{M_k^2-m_{\eta_R^0}^2}ln\frac{m_{\eta_R^0}^2}{\mu^2}\} \tag{A.9}$$

and

$$I_{\eta_I^0}=\frac{h_{ik}h_{jk}M_k i}{16\pi^2}\{\frac{2}{\varepsilon}+1-ln\frac{M_k^2}{\mu^2}+\frac{m_{\eta_I^0}^2}{M_k^2-m_{\eta_I^0}^2}ln\frac{m_{\eta_I^0}^2}{\mu^2}\}. \tag{A.10}$$

Further, on subtracting the integrals we get:

$$I_{\eta_R^0}-I_{\eta_I^0}=h_{ik}h_{jk}M_k\frac{i}{16\pi^2}\left[B_0(0,M_k^2,m_{\eta_R^0}^2)-B_0(0,M_k^2,m_{\eta_I^0}^2)\right]$$

$$=i\frac{h_{ik}h_{jk}}{16\pi^2}M_k\left[\left\{\frac{m_{\eta_R^0}^2}{M_k^2-m_{\eta_R^0}^2}ln\frac{m_{\eta_R^0}^2}{M_k^2}+\frac{2}{\varepsilon}\right\}-\left\{\frac{m_{\eta_I^0}^2}{M_k^2-m_{\eta_I^0}^2}ln\frac{m_{\eta_I^0}^2}{M_k^2}+\frac{2}{\varepsilon}\right\}\right]$$

$$=i\frac{h_{ik}h_{jk}}{16\pi^2}M_k\left[\frac{m_{\eta_R^0}^2}{M_k^2-m_{\eta_R^0}^2}ln\frac{m_{\eta_R^0}^2}{M_k^2}-\frac{m_{\eta_I^0}^2}{M_k^2-m_{\eta_I^0}^2}ln\frac{m_{\eta_I^0}^2}{M_k^2}\right]. \tag{A.11}$$

So far we have only evaluated a quantum correction to the neutrino propagator, whereas we must link it to the *radiative mass of the neutrino*. This can be done by multiplying eq.(A.11) by i which yields the resultant mass[13] as:

$$M_{ij}^{\nu}=\frac{h_{ik}h_{jk}}{16\pi^2}M_k\left[\frac{m_{\eta_R^0}^2}{m_{\eta_R^0}^2-M_k^2}ln\frac{m_{\eta_R^0}^2}{M_k^2}-\frac{m_{\eta_I^0}^2}{m_{\eta_I^0}^2-M_k^2}ln\frac{m_{\eta_I^0}^2}{M_k^2}\right]. \tag{A.12}$$

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PAPER PRESENTED IN WORKSHOP/CONFERENCE

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1. **L. Sarma** and M.K. Das, "Connecting baryogenesis and dark matter in Scotogenic model": **Presented in an International Conference on Emerging Isuues in Cosmology and Particle Physics**, 2020, Vishwa Bharati, Shantiniketan.

2. **L. Sarma** and M.K. Das, "N_1 leptogenesis in Scotogenic model within the intermediate dark matter mass range": **Presented in a National Conference on Trends in Modern Physics**, 2020, Assam Don Bosco University, Assam.

3. **L. Sarma**, B.B. Boruah and M.K. Das, "Sterile dark matter and N_1 leptogenesis in a flavor symmetric ν2HDM framework": **Presented at XXIV DAE-BRNS HEP Symposium**, 2020.

4. **L. Sarma**, B.B. Boruah and M.K. Das, "Neutrinoless double beta decay in a flavor symmetric scotogenic model": **Presented at International Conference on Trends in Modern Physics**, 2021, Assam Don Bosco University, Assam.

5. **L. Sarma** and M.K. Das, "Impact of one zero textures on baryogenesis in a flavor symmetric scotogenic model": **Presented at XII Biennial National Conference of Physics Academy of North East (PANE)**, 2021.

LIST OF PUBLICATIONS

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1. **Sarma, L.**, Das, P. & Das., M. K.; *Scalar dark matter and leptogenesis in the minimal Scotogenic Model*, **Nuclear Physics B 963 (2021) 115300, arXiv: 2004.13762** .

2. Boruah, B. B., **Sarma, L.** & Das, M. K.; *Lepton flavor violation and leptogenesis in discrete flavor symmetric scotogenic model* **Nuclear Physics B 969 (2021) 115472, arXiv:2103.05295**.

3. **Sarma, L.**, Boruah., B. B., & Das, M. K.; *Dark matter and low scale leptogenesis in a flavor symmetric neutrino two Higgs doublet model(ν2HDM)*, **European Physical Journal C, 82 (2022) 5, 488, arXiv:2106.04124**.

4. **Sarma, L.**, & Das, M. K.; *Phenomenology of one zero texture Yukawa matrix in a flavor symmetric scotogenic model*, **International Journal of Modern Physics A 37 (2022) 14, 2250083, arXiv: 2111.08263**.

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- **Sarma, L.**, Boruah., B. B., & Das, M. K.; Neutrinoless double beta decay in a flavor symmetric scotogenic model, **Springer Proceedings 265 (2022) 217-222** of the conference, International Conference on Trends in Modern Physics -2021.

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