

Leptogenesis from Dark Matter Annihilations in Scotogenic Model

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We address the possibility of realising successful leptogenesis from dark matter annihilations in the scotogenic model of neutrino masses to explain the same order of magnitude abundance of dark matter and baryons in the present Universe. After showing that the minimal model in this category can not satisfy all these requirements, we study a minimal extension of this model and find that the scale of leptogenesis can be as low as 5 TeV, lower than the one in vanilla leptogenesis scenario in scotogenic model along with the additional advantage of explaining the baryon-dark matter coincidence. Due to such low scale, the model remains predictive at dark matter direct detection and rare decay experiments looking for charged lepton flavour violating processes.

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1. Failure of Vanilla Scotogenic Model

The scalar DM annihilations can produce a net lepton asymmetry after the annihilation rates go out of equilibrium.

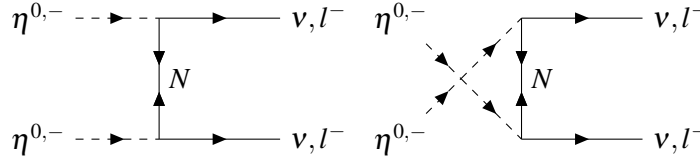


Figure 1: Feynman diagrams corresponding to the annihilation/co-annihilation processes in $\langle\sigma v\rangle_{\text{CDM CDM}\rightarrow\text{LL}}, \langle\sigma v\rangle_{\text{CDM CDM}\rightarrow\text{L WDM}}$.

Now the major downfall of the model comes from the Direct Detection constraints arising from tree level Z boson mediated processes $\eta_{Rn} \rightarrow \eta_{Ln}$, n being a nucleon. Which gives a bound of about $\lambda_5 \approx 1.65 \times 10^{-7} \left(\frac{\delta}{100 \text{ keV}}\right) \left(\frac{M_{\text{DM}}}{100 \text{ GeV}}\right)$. Now in order to satisfy the above relation we would require lower λ_5 which in turn would conflict with lower bound required for the neutrino mass. In order to alleviate this tension we need to incorporate another singlet scalar.

2. Conclusion

We have addressed the possibility of explaining the coincidence of DM abundance and baryon asymmetry in the present Universe along with non-zero neutrino masses within the framework of scotogenic model. Adopting the WIMPy leptogenesis framework and considering the minimal scotogenic model, we first show that the simultaneous generation of DM abundance and baryon asymmetry along with satisfying neutrino mass, DM direct detection data is not possible. We then minimally extend the model by another complex singlet[?] and found that it is indeed possible to explain $\Omega_{\text{DM}} \approx 5\Omega_B$ along with satisfying all other phenomenological constraints. For the two benchmark points chosen in our work, we could obtain successful leptogenesis along with other requirements for $M_{\text{DM}} \sim 5 \text{ TeV}$ whereas vanilla leptogenesis in scotogenic model works for $M_R \geq 10 \text{ TeV}$ [?]. The model can still be tested at near future run of direct detection experiments like Xenon and rare decay experiments looking for charged lepton flavour violation like $\mu \rightarrow e\gamma, \mu \rightarrow 3e, \mu$ to e conversion etc.

References

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