Chapter 5

Conclusion and Future Prospectives

5.1 Introduction

This chapter covers the overall conclusion about the above-discussed research work presented in the earlier chapters, which mainly addresses the topic of connecting neutrino masses along with other neutrino mixing phenomenology with recent modern cosmological phenomena.

In chapter 1, we review recent advances in the field of experimental and theoretical neutrino physics research. We discuss the Standard Model of particle physics and the drawbacks of the model that need its extension. Following this, we delve into the fascinating realms of neutrino flavor oscillations, exploring their occurrences in both matter and vacuum. Within this exploration, we intricately unravel the dynamics of lepton number violation and lepton flavor violation, shedding light on these captivating low-energy processes. The dark matter and the baryon asymmetry of the universe are two more important cosmological issues that this chapter has addressed and which need BSM frameworks. We discuss various mechanisms of generating neutrino mass using discrete flavor symmetry groups like A_4 and $\Delta(27)$, different types of seesaw mechanisms like Type-I, Type-

II, Type-III, Inverse seesaw mechanism, and neutrinoless double beta decay. We focus on mainly flavor symmetry groups like A_4 and $\Delta(27)$ with Z_2, Z_3, Z_5, Type-I seesaw mechanism and neutrinoless double beta decay as these are used in our thesis work.

In chapter 2, we discuss about the modification of the Altarelli-Feruglio A_4 flavor symmetry model by adding three singlet flavons ξ', ξ'' and ρ and the model is augmented with extra cyclic symmetry $Z_2 \times Z_3$ to prevent the unwanted terms in our study. The addition of these three flavors leads to two higher order corrections in the form of two perturbation parameters ϵ and ϵ'. These corrections yield the deviation from the exact tri-bimaximal (TBM) neutrino mixing pattern by producing a non-zero θ_{13} and other neutrino oscillation parameters which are consistent with the latest experimental data. In both the corrections, the neutrino masses are generated via Weinberg operator. The analysis of the perturbation parameters ϵ and ϵ', shows that normal hierarchy (NH) and inverted hierarchy (IH) for ϵ does not change much. However, as the values of ϵ' increase, θ_{23} occupies the lower octant for NH case. We further investigate the neutrinoless double beta decay parameter $m_{\beta\beta}$ using the parameter space of the model for both normal and inverted hierarchies of neutrino masses.

In chapter 3, we study a neutrino mass model with A_4 discrete flavor symmetry using a type-I seesaw mechanism. The inclusion of extra flavons in our model leads to deviations from the exact tribimaximal mixing pattern resulting in a nonzero θ_{13} consistent with the recent experimental results and a sum rule for light neutrino masses is also obtained. In this framework, a connection is established among the neutrino mixing angles- reactor mixing angle(θ_{13}), solar mixing angle(θ_{12}), and atmospheric mixing angle (θ_{23}). This model also allows us a prediction of Dirac CP-phase and Jarlskog parameter J. The octant of the atmospheric mixing angle θ_{23} occupies the lower octant. Our model prefers normal hierarchy (NH) to inverted hierarchy (IH). We use the parameter space of our model of neutrino masses to study the neutrinoless double beta decay parameter m_{ee}.

In chapter 4, we present a neutrino mixing model based on the discrete flavor symmetry group $\Delta(27)$ and supplemented by other cyclic symmetries Z_3 along with the seesaw mechanism to explain the observation of a non-zero reactor mixing angle θ_{13}. This kind of mass matrix easily produces mixing patterns that realistically deviate from tribimaximal mixing, including mixing patterns with non-zero θ_{13}. It explains the hierarchies of the charged leptons. Our model allows us to determine the Dirac CP violation phase as a function of the mixing angles θ_{12}, θ_{23}, θ_{13}. Both the normal ordering and the inverse ordering of the neutrino masses are quite close to the global fits of the experimental data.

5.2 Future prospectives

Finally, in this **chapter 5** we present the summary and conclusion of the thesis work. The main goal of this thesis work is to develop models employing discrete flavor symmetry within various BSM frameworks. In this thesis, we have incorporated the type-I seesaw mechanism—chosen to address the limitations of the SM. Three chapters are dedicated to unraveling the mysteries of the phenomenology of neutrino mass and mixing. We also discuss extensively phenomenology like neutrinoless double beta decay.

Though there are numerous possibilities, to explore in this field. Realization of these models could be done with the help of inverse seesaw models, which can naturally generate neutrino masses that are much smaller than the Majorana masses of sterile neutrinos, even without fine-tuning parameters. The inverse seesaw model can be used to get more confined and predictive models, increasing their viability. We could study dark matter also as the type 1 seesaw model introduces right-handed Majorana neutrinos, often much heavier than the familiar left-handed ones. Some models propose that these "sterile" neutrinos, which interact only weakly with regular matter, could themselves be dark matter candidates.