Abstract

The Standard Model of particle physics has proven highly effective in elucidating the interactions of fundamental particles across diverse energy scales. In spite of its enduring experimental success several shortcomings including the origin of neutrino mass, baryon asymmetry and dark matter plagues its edifice. In this thesis we explore some of the phenomenological consequences of neutrino mass models in the context of generation of baryon asymmetry through leptogenesis and freeze-in dark matter.

The origin of the experimentally indicated CP violating phase in the neutrino mass matrix remains mystifying. We provide a minimal model for generating δ_{CP} spontaneously within a hybrid seesaw framework. In this minimal hybrid framework combining type I and type II seesaw, the CP is broken spontaneously by the complex vacuum expectation value of a scalar singlet. We demonstrate that the model can additionally generate the observed baryon asymmetry through leptogenesis driven by the CP violating outof-equilibrium decay of right handed neutrino and the scalar triplet while remaining in consonance with the neutrino oscillation parameters. Next we focus on a detailed analysis of hybrid type I + II seesaw model with quasi degenerate mass scales. We demonstrate that a systematic inclusion of often neglected mixed scattering processes can significantly alter the evolution of the number densities. This is shown to induce up to a factor ten deviation in the predicted baryon asymmetry. We provide quantitative constraints on the degeneracy of the seesaw scales where this phenomenon becomes numerically significant.

Finally we explore the possibility of cogenesis of visible and dark matter from a primordial thermal dark sector. Within the context of a multi generational scotogenic model for neutrino mass we show the possibility of a CP violating decay of a heavy dark particle simultaneously populating the visible and dark sectors. While the CP violation accounts for the observed asymmetry in the visible sector, a novel competition between the scattering with the primordial soup and decay of the next-to-lighest dark sector particle is responsible for setting the dark matter relic density with a viable sub-GeV freeze-in dark matter.

Keywords: Neutrino mass models, CP violation, leptogenesis, dark matter.