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Chapter 9: Study of neutrino parameters from texture zero in the neutrino mass matrix using Mathematica

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Abstract: Neutrino oscillation parameters play a pivotal role in determining a complete study of the neutrino sector. Owing to its inadequacy from current experimental data, here we aim to study the parameters considering texture zero in the neutrino mass matrix. More specifically we consider the unknown neutrino parameters, the atmospheric mixing angle, Dirac CP violating phase and the absolute neutrino mass scale.

Keywords: neutrino oscillation, mass matrix, texture-zero, beyond standard model

Introduction

The milestone discovery of the Higgs Boson also known as the God particle at the Large Hadron Collider (LHC) in 2012 completed the most successful Standard model (SM) (1) of particle physics. Notwithstanding there are certain inadequacies in this celebrated model as it fails to answer the origin and mass of the most elusive fermion, the neutrinos. Neutrino oscillation phenomenon and its experimental verification which bagged the 2015 Nobel Prize in Physics has proved that this tiny particle has mass and they mix while propagation. This brings into light several beyond Standard Model (BSM) frameworks to study the less precisely known parameters the Dirac CP phase, octant of atmospheric mixing angle (that is, whether it is greater or less than 45^0) and the ordering of light neutrinos: normal ordering (NO) or inverted ordering (IO) (that is whether the masses of the mass eigenstates ν_1, ν_2 and ν_3 follows the sequence $m_1<m_2<m_3$ or $m_3<m_1<m_2$, the intrinsic nature of neutrinos (whether Dirac or Majorana) in the neutrino sector as well as the underlying mass generation mechanism and mixing of the neutrinos. Neutrinoless double beta decay (NDBD) is one of the rarest decay processes, the observation of which could prove one of the important characteristics of this elusive particle, its intrinsic nature that it is a Majorana fermion (particle is identical to its antiparticle). Out of several experiments, the latest experiment KamLAND-Zen imposes the best lower limit on the decay half-life using Xe-136 as $T_{1/2}{}^{0\nu} > 3.8\times10^{26}$ yr at 90% CL (2) and the corresponding upper limit of effective Majorana neutrino mass in the range (0.022-0.12) eV. Cosmological data from PLANCK also constrains the sum of the absolute neutrino masses as $|mi| < 0.12$ eV (3). While observations from cosmology and NDBD provides stringent constraints on the neutrino properties, direct mass measurement methods like that adopted in Karlsruhe Tritium Neutrino Experiment) could measure the incoherent sum of neutrino masses with unprecedented accuracy with the latest limit being $m_\nu<0.45\ eV$ (4). The BSM frameworks may also address several other cosmological issues like the