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Active–Sterile Neutrino Oscillations: Matter Effects in Scotogenic Models with Gauged \(U(1)_{B-L}\) Symmetry

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The observation by KM3NeT of a neutrino with an energy exceeding \(100\,\mathrm{PeV}\) motivates the study of scenarios that could account for this event alongside the absence of comparable events in IceCube. One possibility is that sterile-to-active neutrino conversion depends on propagation conditions within the Earth. For the geometry considered, the estimated propagation distances are approximately \(147\,\mathrm{km}\) through rock and water before reaching KM3NeT and \(14\,\mathrm{km}\) through ice before reaching IceCube. This difference motivates the hypothesis of an astrophysical sterile neutrino flux whose conversion into active states is modified by matter effects. In this work, we study two extensions of the Standard Model with gauged \(U(1)_{B-L}\) symmetry, in which a new \(Z'\) boson mediates interactions between neutrinos and terrestrial matter, while a scotogenic sector generates radiative contributions to neutrino masses and active–sterile mixing. We analyze how these interactions modify conversion probabilities and assess their implications for both detectors. We also explore the phenomenology of the dark matter candidates present in these models.

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