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Astrophysical Insights into Pseudo-Dirac Neutrinos with IceCube Observations

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Neutrinos, while often considered as Majorana fermions, can also behave as effectively Dirac fermions, making them candidates for pseudo-Dirac particles. This concept introduces the possibility of oscillations between active and sterile neutrinos, driven by a small mass-squared difference. This phenomenon differs from the standard oscillation scenario involving only the three active neutrino flavors observed across astrophysical distances. In this study, we focus on analyzing publicly available data from the IceCube neutrino observatory, searching for potential pseudo-Dirac signatures in high-energy neutrinos emitted from astrophysical sources such as NGC 1068, TXS 0506+056 and PKS 1424+240. In the pseudo-Dirac framework, the active neutrino flux from these sources diminishes due to their oscillation into sterile states. By employing astrophysical flux models, we fit the IceCube data for these sources under both the standard neutrino oscillation framework and the active-sterile oscillation scenario. This enables us to place constraints on the mass-squared difference driving the active-sterile oscillations, as well as on the intrinsic source flux. These constraints could be improved by future neutrino observatories such as KM3NeT and IceCube Gen-2.

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