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Dark Matter and Neutrino Masses at 3-Loops: Classification and experimental signatures

Radiatively induced neutrino masses via dark matter interactions link two different physical phenomena that separately require physics beyond the Standard Model. In addition to having a dark matter particle candidate, these scenarios provide a natural explanation for the smallness of neutrino masses compared to the electroweak scale. We investigate the framework where the new physics that breaks lepton number and induces neutrino masses only couples to the Standard Model's charged leptons of right-handed chirality. A unique lowest order $D = 9$ lepton number breaking effective operator, $\mathcal{O}_9$, emerges in this context. We show that there are only two possible classes of new physics that can form the UV completions to such $\mathcal{O}_9$ operator and induce neutrino masses at 3-loop level in the presence of dark matter. We discuss the generic constraints and predictions of different realizations in each class, and analyze the important interplay between neutrino mixing and neutrinoless double-β decay in these scenarios to either rule them out or give characteristic signals of beyond standard model physics.

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