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A comprehensive analysis of supernova neutrino-dark matter interactions

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We present a comprehensive analysis of nonstandard neutrino interactions with the dark sector in an effective field theory (EFT) framework, considering {\it exact} analytic formulae for the differential scattering cross sections of neutrinos with scalar, fermionic, and vector dark matter (DM) for dark sector models with mediators of different spins. We then implement the full catalog of constraints on the parameter space of the neutrino-dark matter/mediator couplings and masses, including cosmological/astrophysical bounds coming from Big Bang Nucleosynthesis, Cosmic Microwave Background, DM/neutrino self-interactions, DM collisional damping, thermal relic density, and SN1987A, as well as laboratory constraints from neutrinoless double decay, 3-body meson decays and invisible Z decays. To illustrate the practical consequences of our new results, we take the galactic supernova neutrinos in the MeV energy range as a concrete example and highlight the difficulties in finding any observable effect of neutrino-DM interactions. Finally, we identify new benchmark points potentially promising for future observational prospects of the attenuation of the neutrino flux of a galactic supernova and comment on their implications for the detection prospects in future large-volume neutrino experiments such as DUNE, Hyper-K and JUNO.

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