A Booster Shot for Cosmic Neutrinos

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ν Introduction

Neutrinos are the most elusive among all Standard Model particles and the gateway to new *beyond-Standard-Model* physics. While they are known to have weak interaction with other leptons, it is interesting to ask if they have other *secret* interaction among themselves. Self-interacting neutrino is an interesting BSM topic and may have observable consequences for many areas, such as the cosmic microwave background, the Hubble tension, stellar cooling, supernova explosion etc. Such self-interaction also means cross-talking between different populations of neutrinos.

ν Methodology

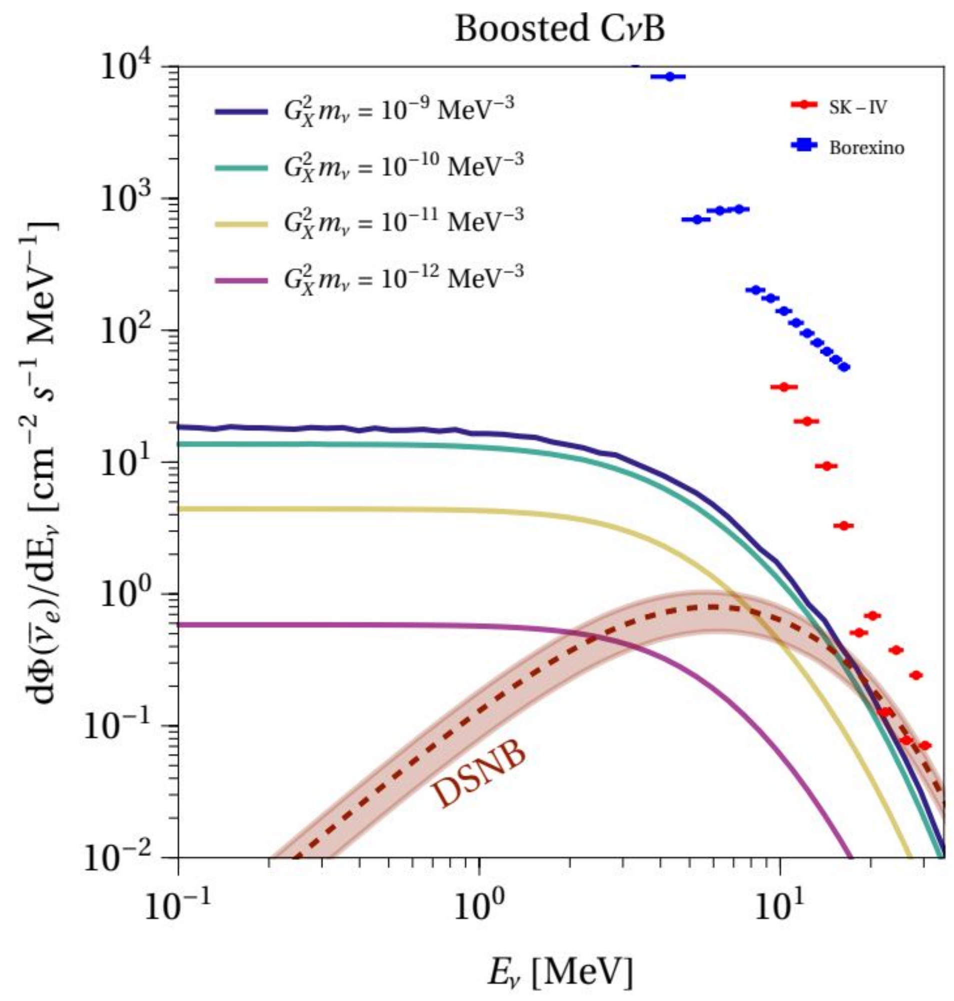
All core-collapse supernovae in the history of the Universe have created a large number of ~ 1-10 MeV energy neutrinos. Collectively, they today form the Diffuse Supernova Neutrino Background (DSNB). It is an isotropic flux of approximately thermal neutrinos.

The relic neutrinos since the time of big bang nucleosynthesis form another ubiquitous part of our Universe, the cosmic neutrino background (CνB). They have been free streaming since electroweak freeze-out around $T \sim 1$ MeV. Today they have very low energy, only ~ $O(0.1$ meV). In the presence of self-interaction, higher energy neutrinos from DSNB can interact and upscatter the cosmic neutrinos to MeV-scale energy. The upscattered flux is given by

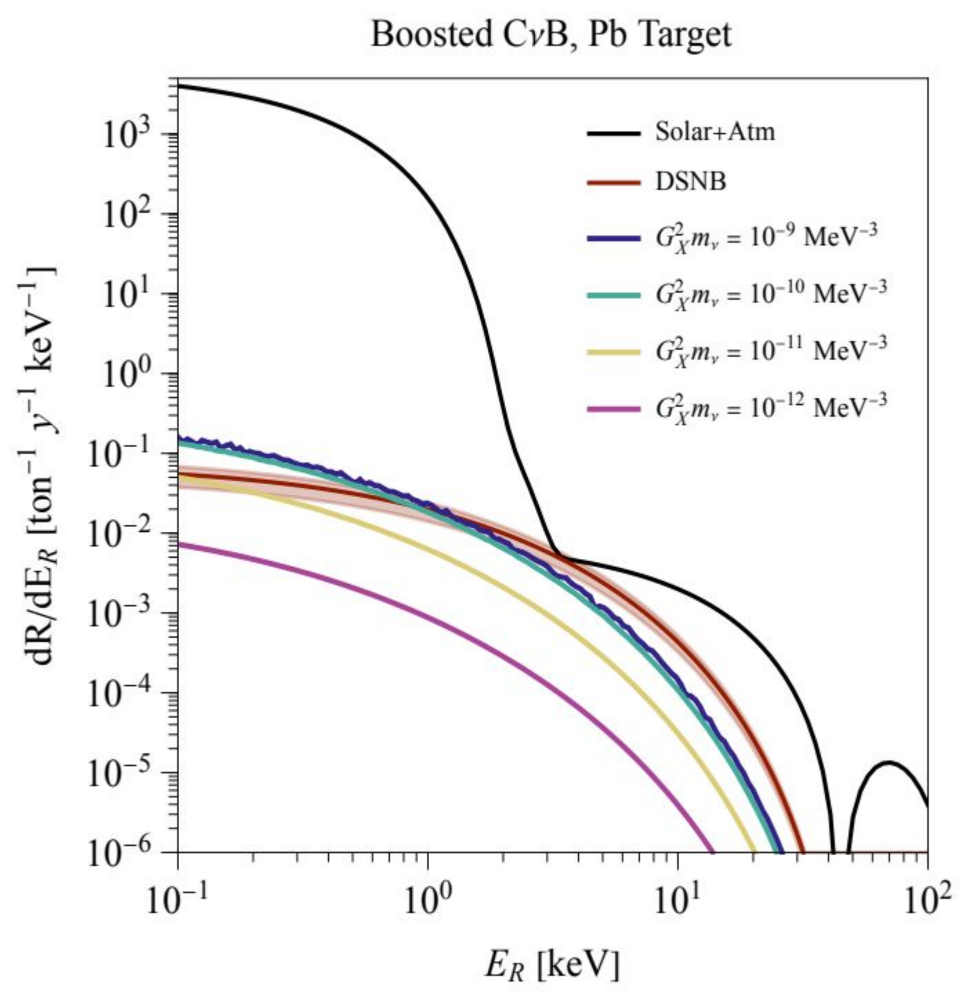
$$\frac{d\psi_C}{dE_C} = \int_{E_C}^{\infty} dE_D \int_0^{z_{\max}} \frac{dz}{H(z)} n_\nu(z) \frac{d\sigma}{dE_C} \frac{d\Phi_D(z)}{dE_D}$$

We integrate the DSNB flux upto a redshift $z_{max} = 6$, and assume a flavor-universal diagonal coupling matrix. The mediator is taken to be heavy compared to the typical energy transferred.

ν Results



The enhanced flux in the 1-10 MeV energy could be observable in present and near-future neutrino detectors aimed to look for DSNB, such as SuperK, JUNO, DUNE etc.



Future experiments using the CEvNS would also be promising with high atomic mass detector like Pb. We show the expected recoil spectrum in such an experiment RES-NOVA. Lower threshold and long exposure will help detect the upscattered neutrinos.

References:

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