Neutrino-Dark Matter Interactions

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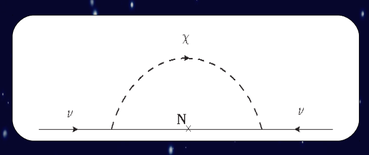
Introduction

Neutrino masses and ***Dark Matter (DM)*** are two of the most compelling evidences of physics beyond the Standard Model (SM). If neutrinos ***interact*** with ***DM*** via a ***mediator***, the ***mass scales*** of the new particles can be constrained by:

Neutrino mass models like radiative models [1]



Relic density, N_{eff} and indirect detection

$$\chi\overline{\chi} \rightarrow \nu_L\,\overline{\nu_L}$$

Imprints on the CMB via collisional damping [2]

$$\chi\,\nu_L \rightarrow \chi\,\nu_L$$

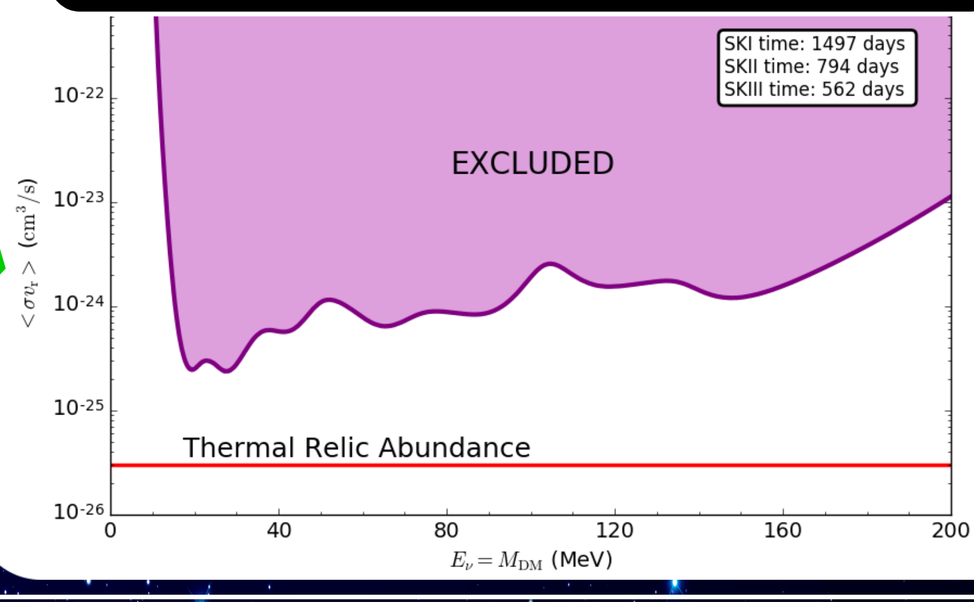
Here we take a ***simplified model approach*** and study different combinations of ***spins*** for the ***DM candidate*** and its ***mediator***.

Scenarios

We consider the different ***scenarios*** where a SM ***left-handed neutrino*** can be coupled to a ***dark matter candidate*** via a ***mediator***. There is a total of 12 ***scenarios***:

DM \ Mediator	Scalar	Fermion	Vector
Scalar	×	✓	✓
Fermion	✓	×	✓
Vector	×	✓	✓

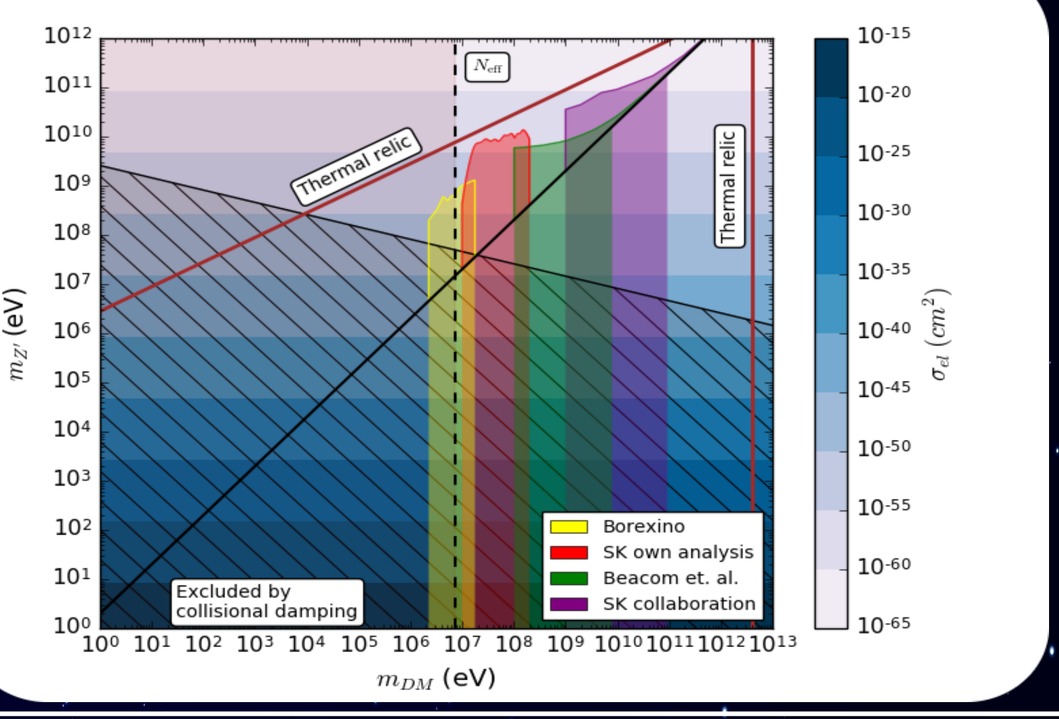
Neutrinos at Super-Kamiokande (SK)



Studying ***data*** from diffuse supernova ***neutrino*** background searches at SK, one can set strong ***bounds*** on the ***DM*** annihilation cross section for ***MeV DM masses.***

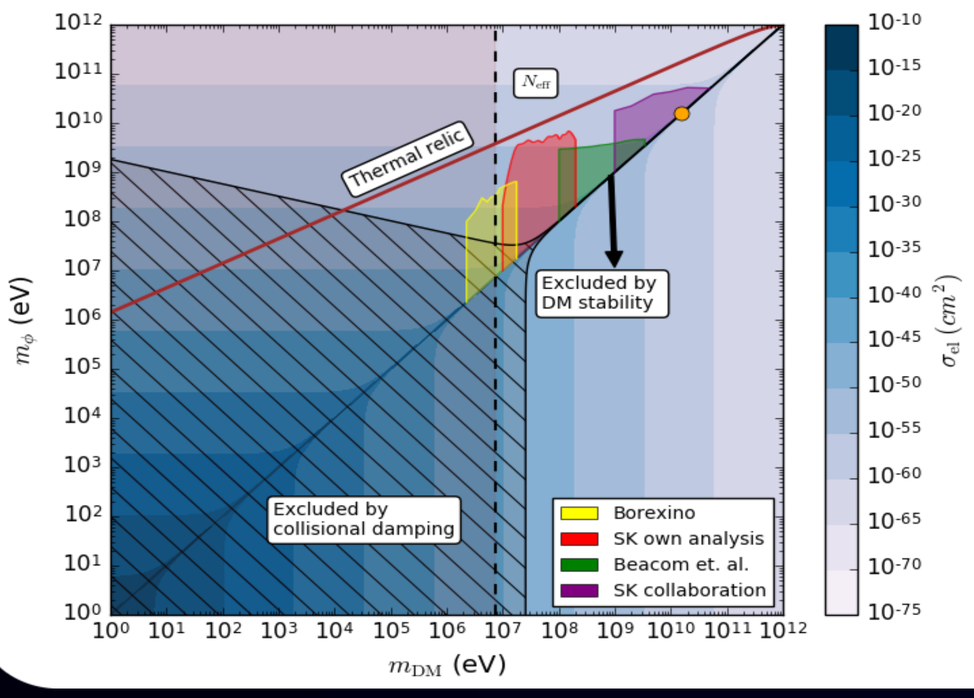
Dirac DM, Vector Mediator

$$\mathcal{L}_{int} \supset -g_\nu \overline{\nu_L}\gamma^\mu Z'_\mu \nu_L - g_{\chi_{L,R}} \overline{\chi_{L,R}}\gamma^\mu Z'_\mu \chi_{L,R}$$



Dirac DM, Scalar Mediator

$$\mathcal{L}_{int} \supset -g\,\phi\,\overline{\chi_R}\,\nu_L + \text{h.c.}$$



The coloured regions show different ***bounds*** from ***indirect detection searches*** [3,4]. The dashed region and the diagonal up to the orange dot (in the figure on the left) is excluded by ***collisional damping*** while the dashed vertical line is the ***DM mass*** lower bound derived by the changes in N_{eff} [5].

Conclusions

- The ***complementarity*** of observational constraints allows us to ***exclude*** a large region of the ***parameter space.***

- The ***phenomenology*** between ***DM*** coupled via spin-1 or spin-0 and spin-1/2 ***mediators*** is ***very different***, with ***DM (mediator)*** masses being ***ruled out*** up to few ***MeV (GeV)*** in the latter.

References

[1] Celine Boehm, Yasaman Farzan, Thomas Hambye, Sergio Palomares-Ruiz and Silvia Pascoli, *Phys. Rev., D77:043516, 2008.*

[2] Ryan J. Wilkinson, Celine Boehm and Julien Lesgourgues, JCAP, 1405:011, 2014.

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[4] Katarzyna Frankiewicz, *Super-Kamiokande Collaboration, arXiv/hep-ex:1510.07999.*

[5] Celine Boehm, Mathew J. Dolan and Christopher McCabe, *JCAP 1308 (2013) 041.*