

Title: Solar neutrinos as a probe of Neutrino-Dark Matter interactions

Date: Jul 21, 2017 04:00 PM

URL: <http://pirsa.org/17070024>

Abstract:



Solar Neutrinos as a Probe of Dark Matter-Neutrino Interaction

based on JCAP **1707** (2017) 07, 021, with I. Shoemaker and L. Vecchi

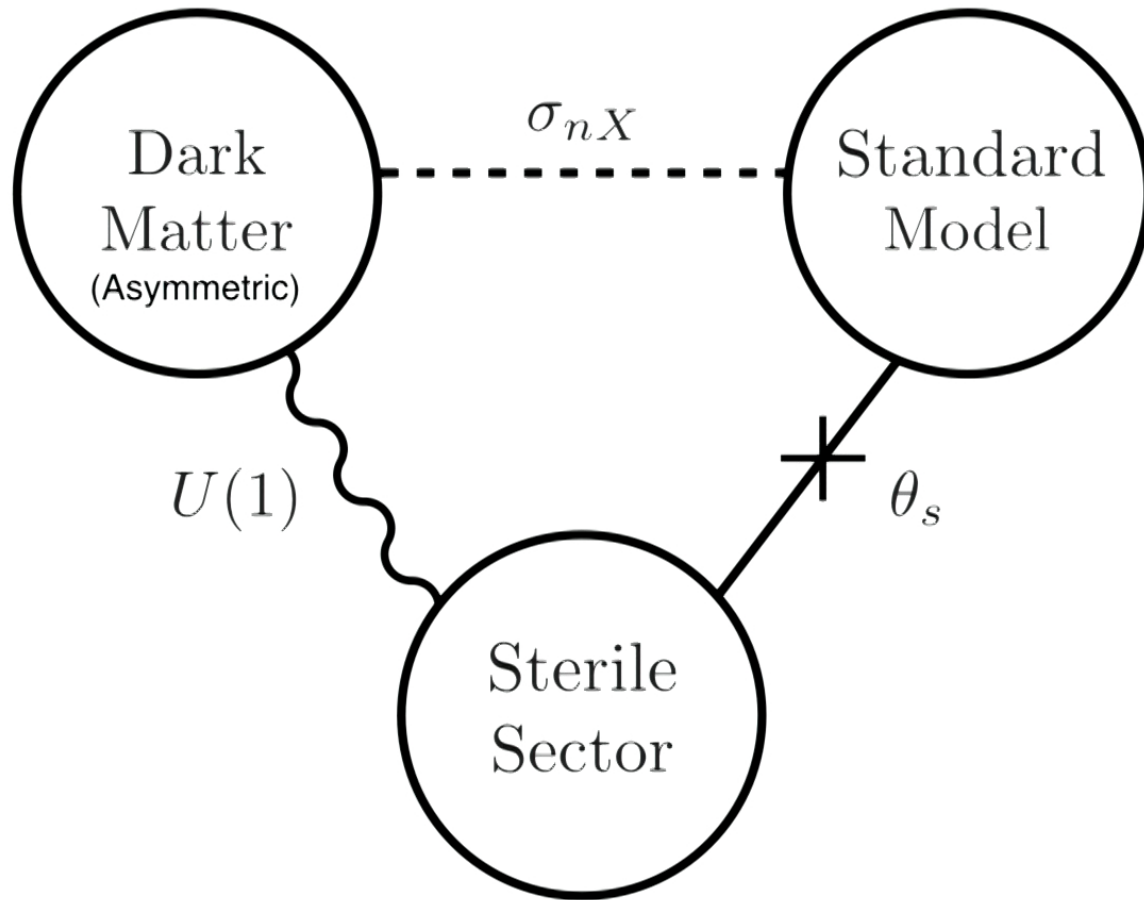
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Model



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WHY THIS MODEL?

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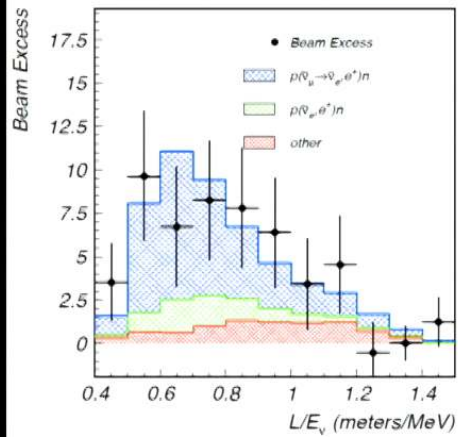
Motivations

Hints for a sterile neutrino at ~ 1 eV

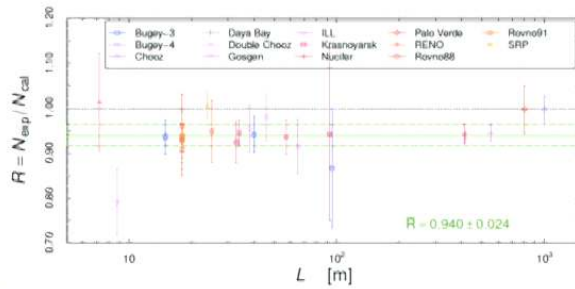
$$\Delta m^2_{\text{SBL}} \sim 1 \text{ eV}^2$$

$$\sin^2\theta \sim 0.01$$

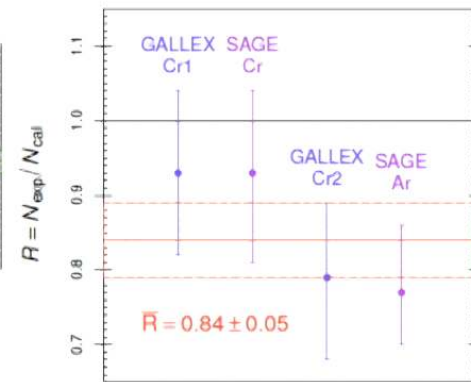
LSND anomaly



REACTOR anomaly

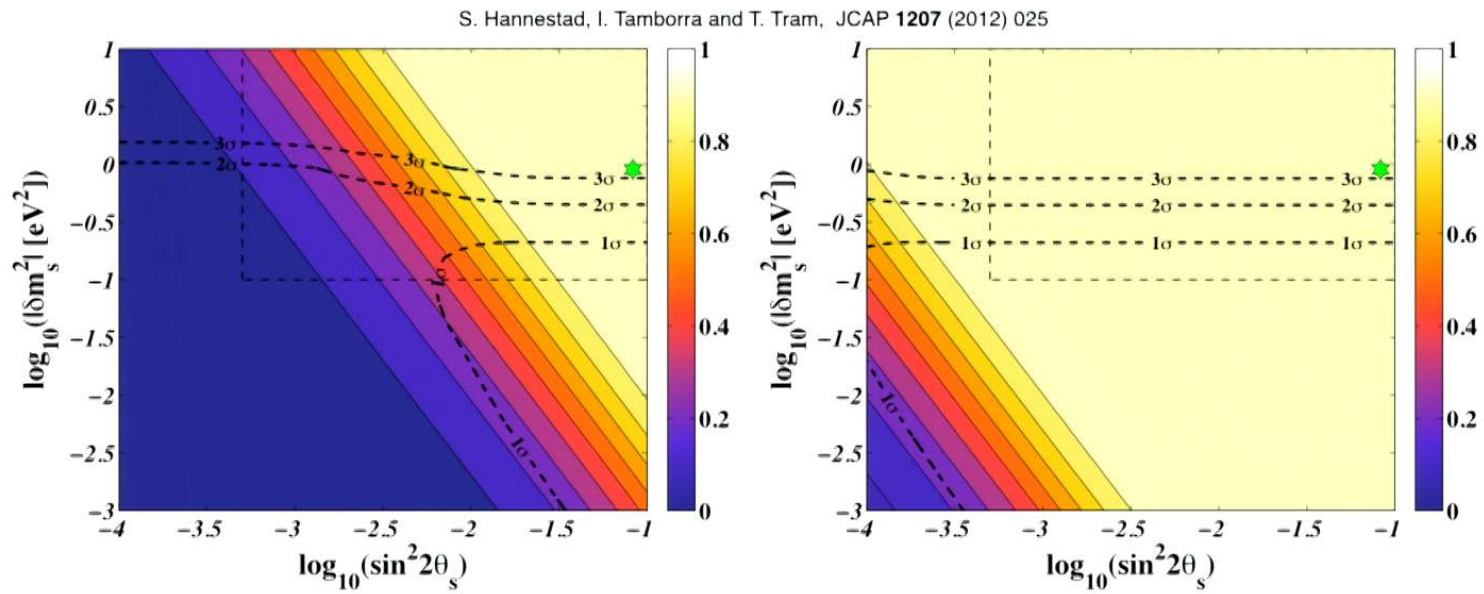


GALLIUM anomaly



Motivations

ν_s secret interactions may reconcile SBL anomalies with Cosmology

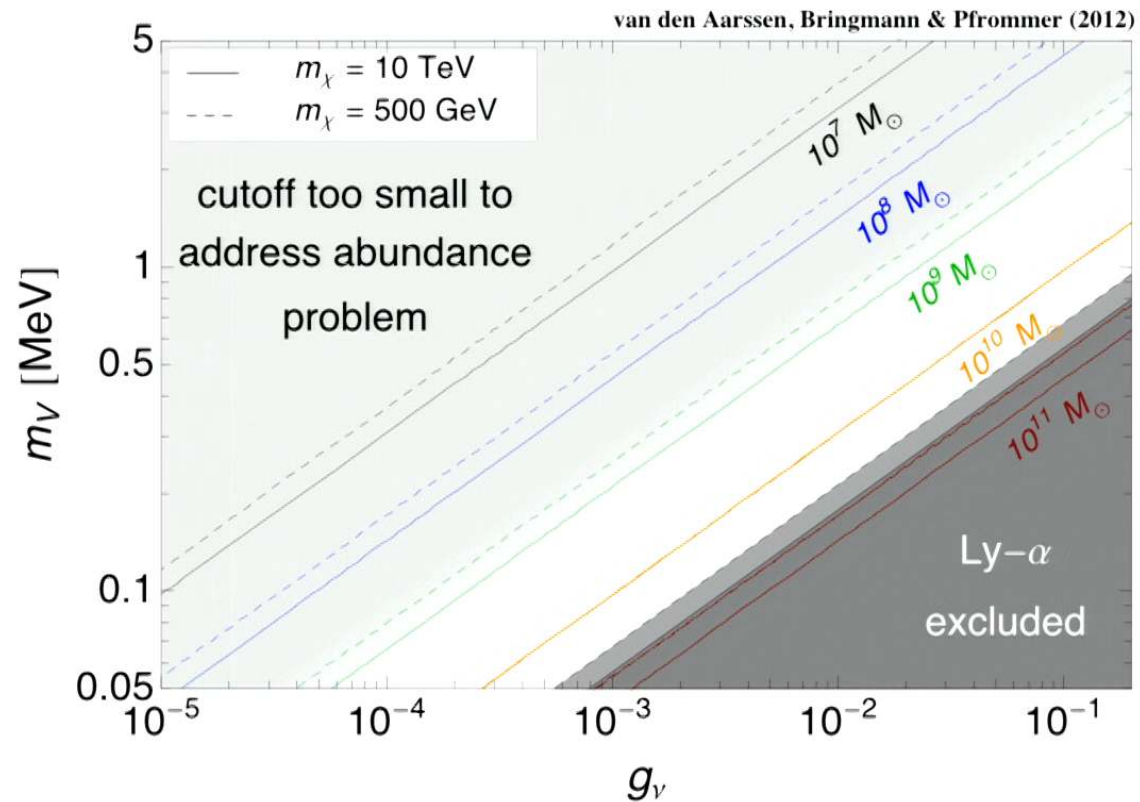


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Motivations

ν - DM interaction may solve the “missing satellite” problem



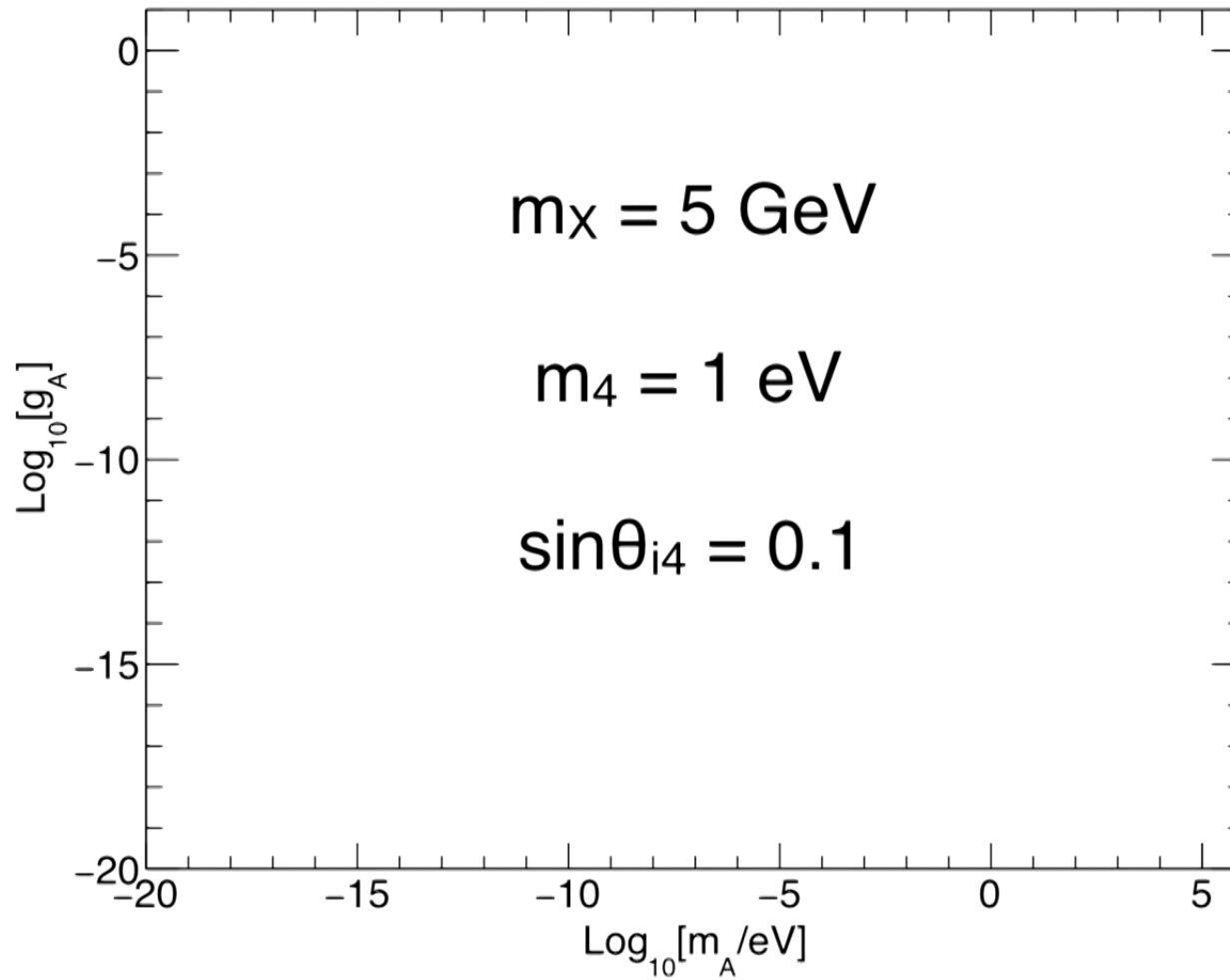
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CONSTRAINTS

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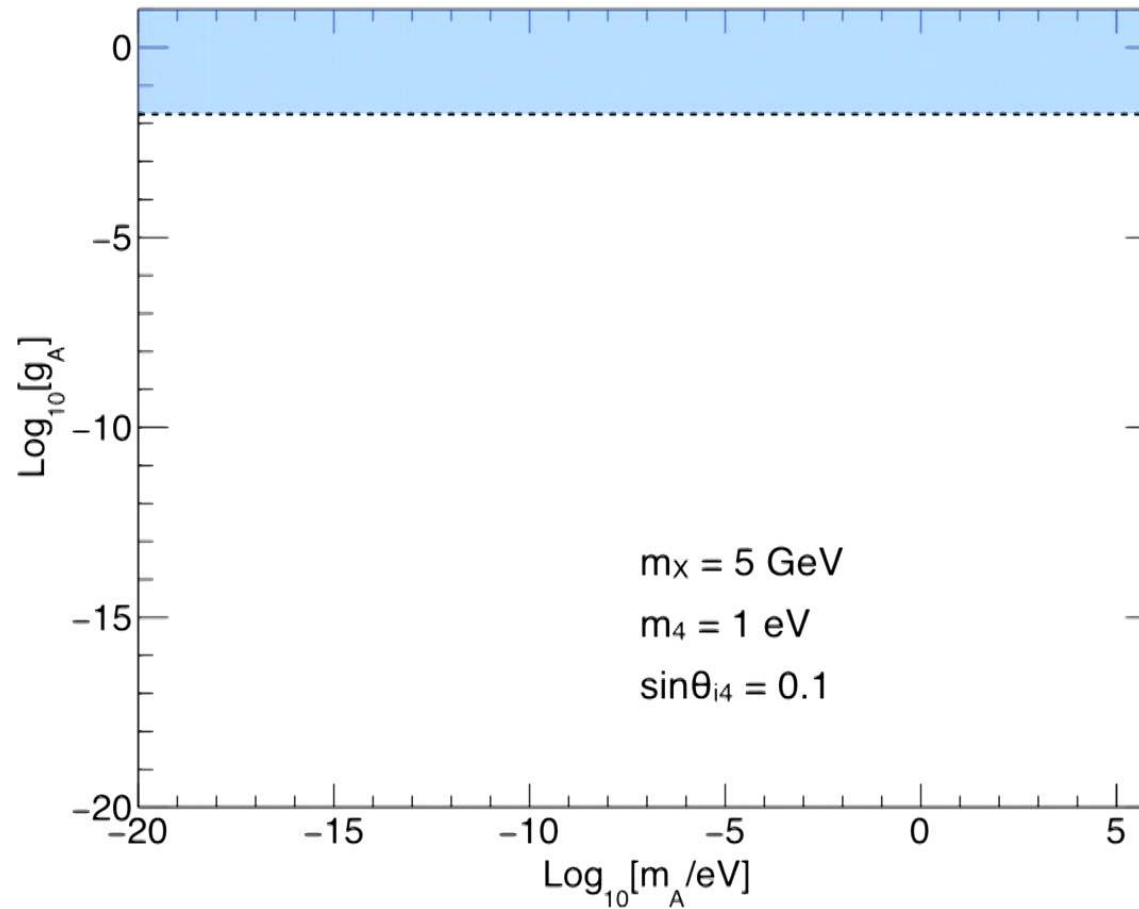


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Constraints: DM self-interaction

Constraint from modification of DM halo ellipticity

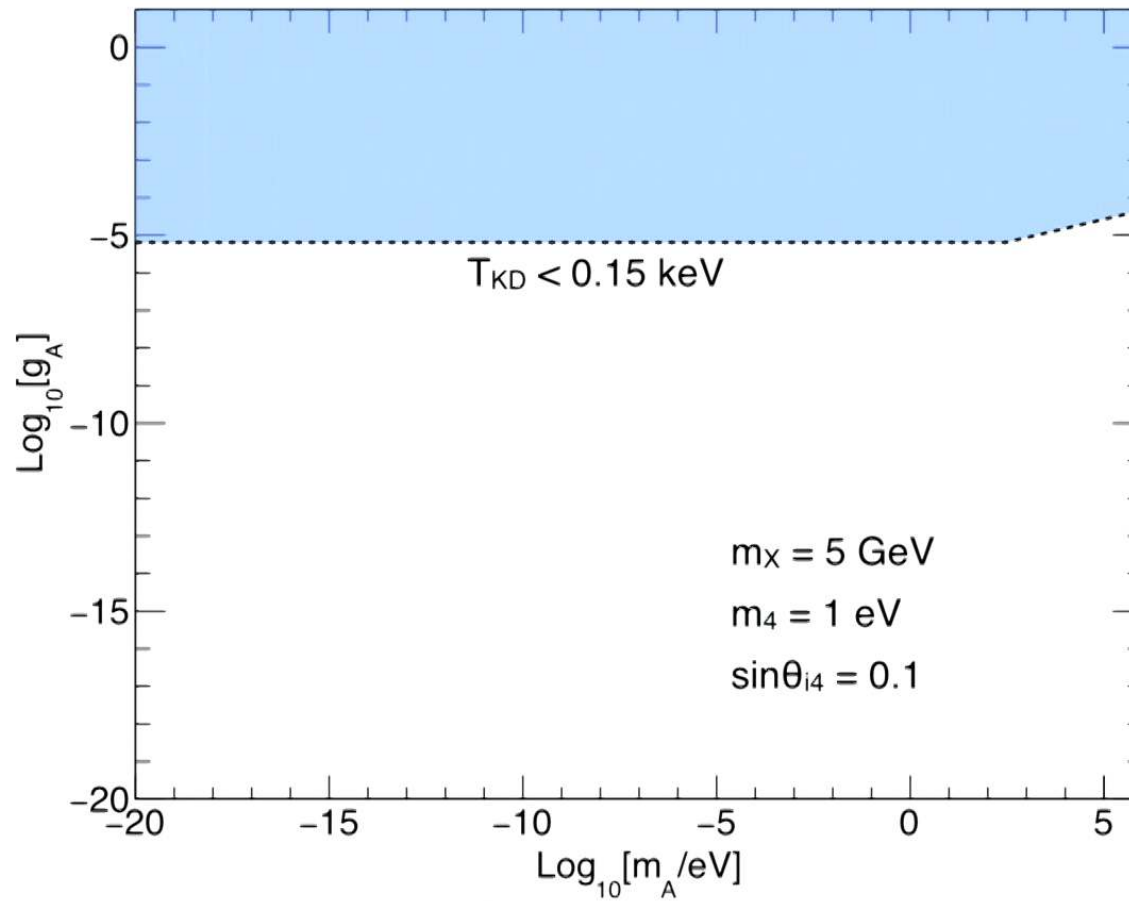


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Constraints: ν -DM interaction

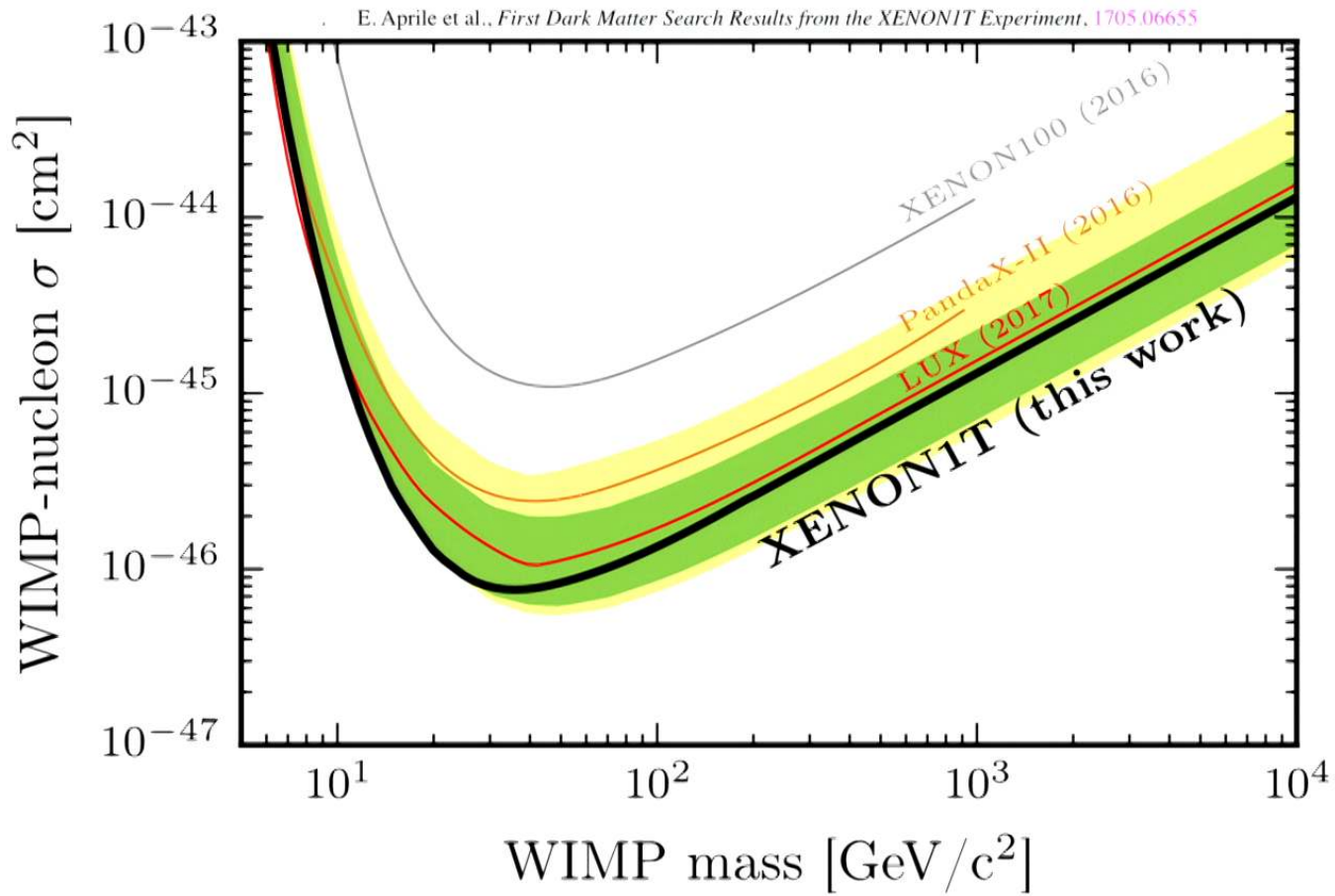
Constraint from Lyman- α : $M_{\text{cut}} < 5 \times 10^{10} M_{\odot}$



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Constraints: $\sigma_{n\chi}$ from direct detection

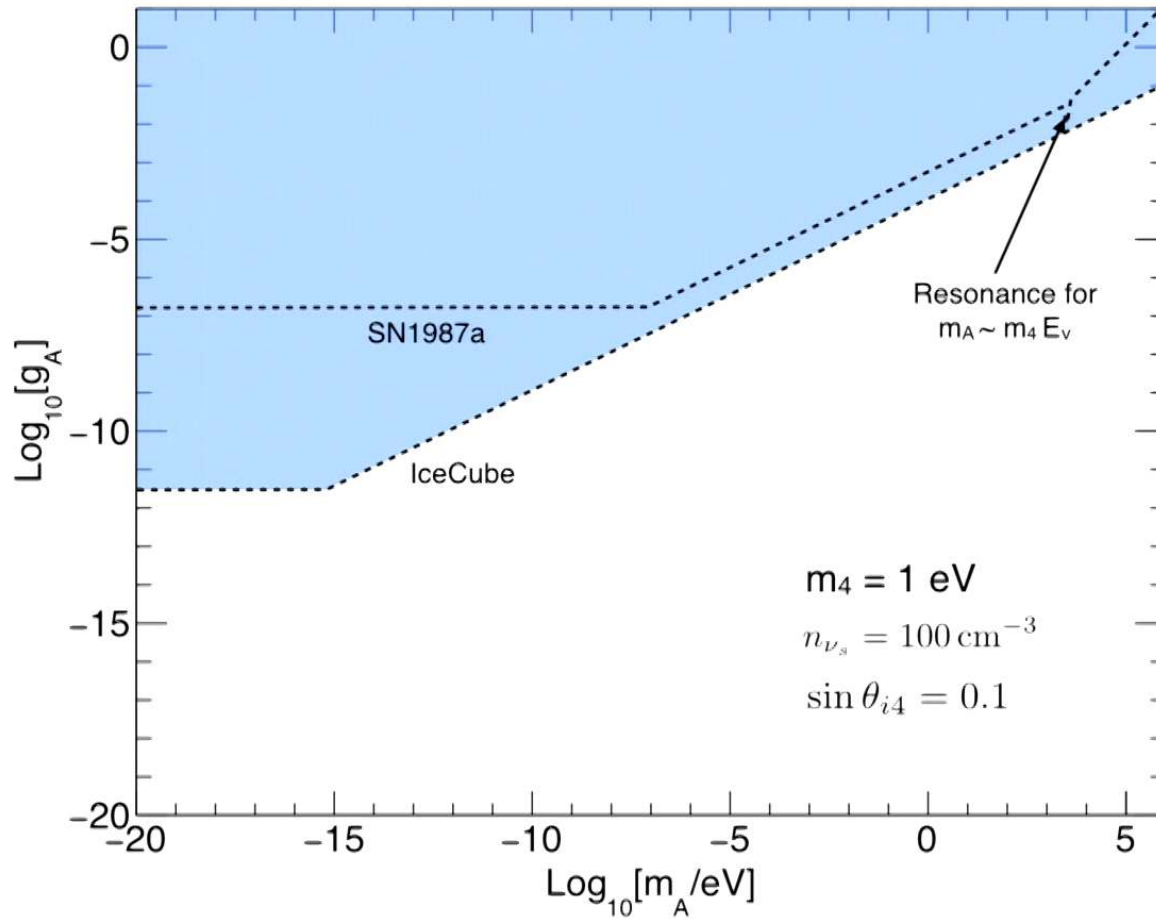


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Constraints: ν scattering on CvB

Constraint from ν interaction with CvB



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MODEL SIGNATURES

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Possible signature: UHEv in DM halo

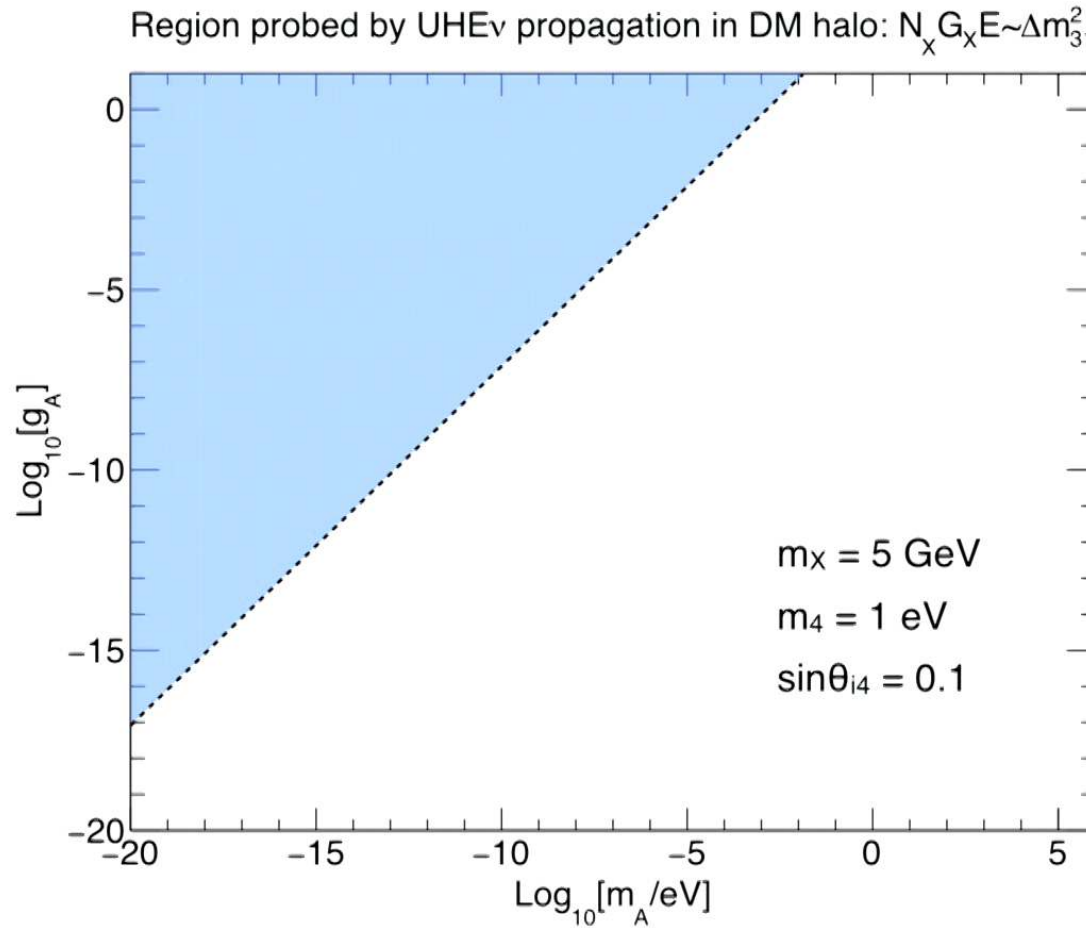
$$V_{\text{eff}} = q_s q_X \frac{g_A^2}{\partial^2 + m_A^2} n_X \simeq q_s q_X \frac{g_A^2}{m_A^2} n_X = G_X n_X$$

If $|q_s|=|q_X|=1$ and $m_A/g_A=1$ eV, we have $G_X/G_F \sim 10^{23}$

Effects on oscillations when:

$$n_X G_X E \gtrsim \Delta m^2$$

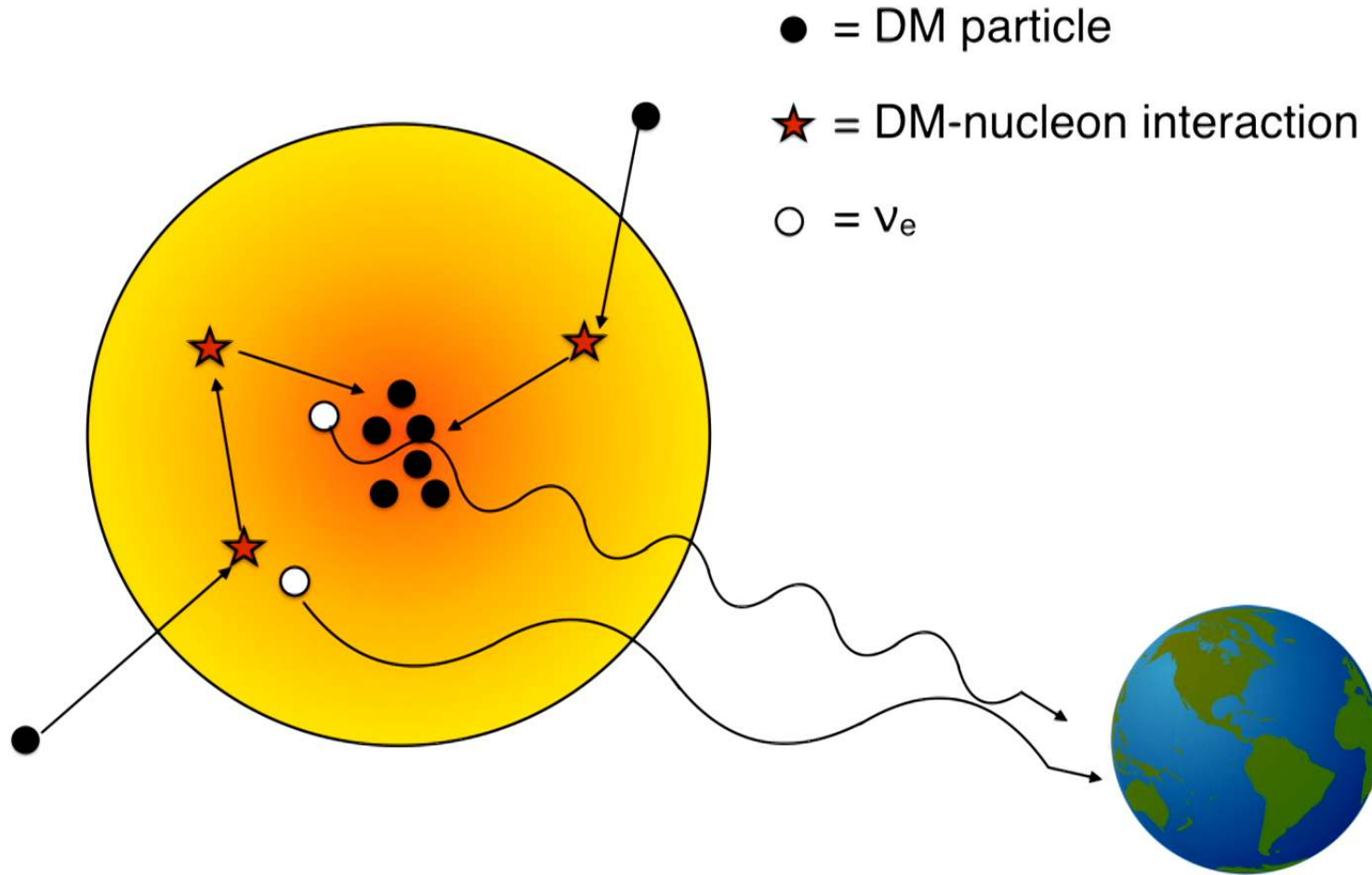
Possible signature: UHEv in DM halo



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Possible signature: solar neutrinos



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DARK MATTER CLUSTERING

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DM in the Sun: thermal region

After thermalization:

$$n_X(r) = \frac{N_X}{r_X^3 \pi^{3/2}} e^{-r^2/r_X^2}$$

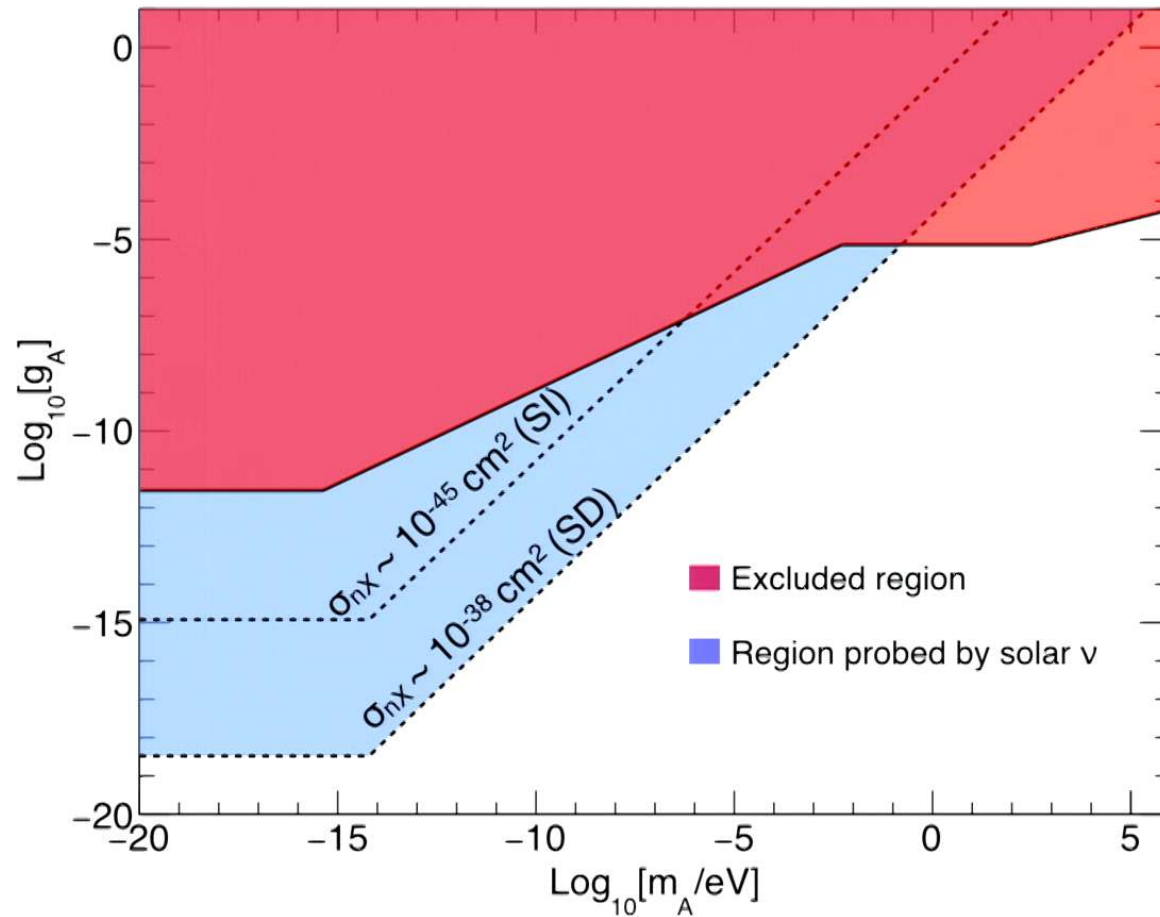
$$r_X(r) = \sqrt{\frac{3T_\odot}{2\pi G_N \rho_\odot m_X}} \sim 0.05 \sqrt{\frac{5\text{GeV}}{m_X}} R_\odot$$

$$T_\odot = 10^7 \text{ K} \qquad \rho_\odot = 150 \text{ g/cm}^3$$

DM in the Sun: how many DM particles?

$$N_X / N_e \sim 10^{-21} \left(\frac{\sigma_{nX}}{10^{-45} \text{cm}^2} \right)$$

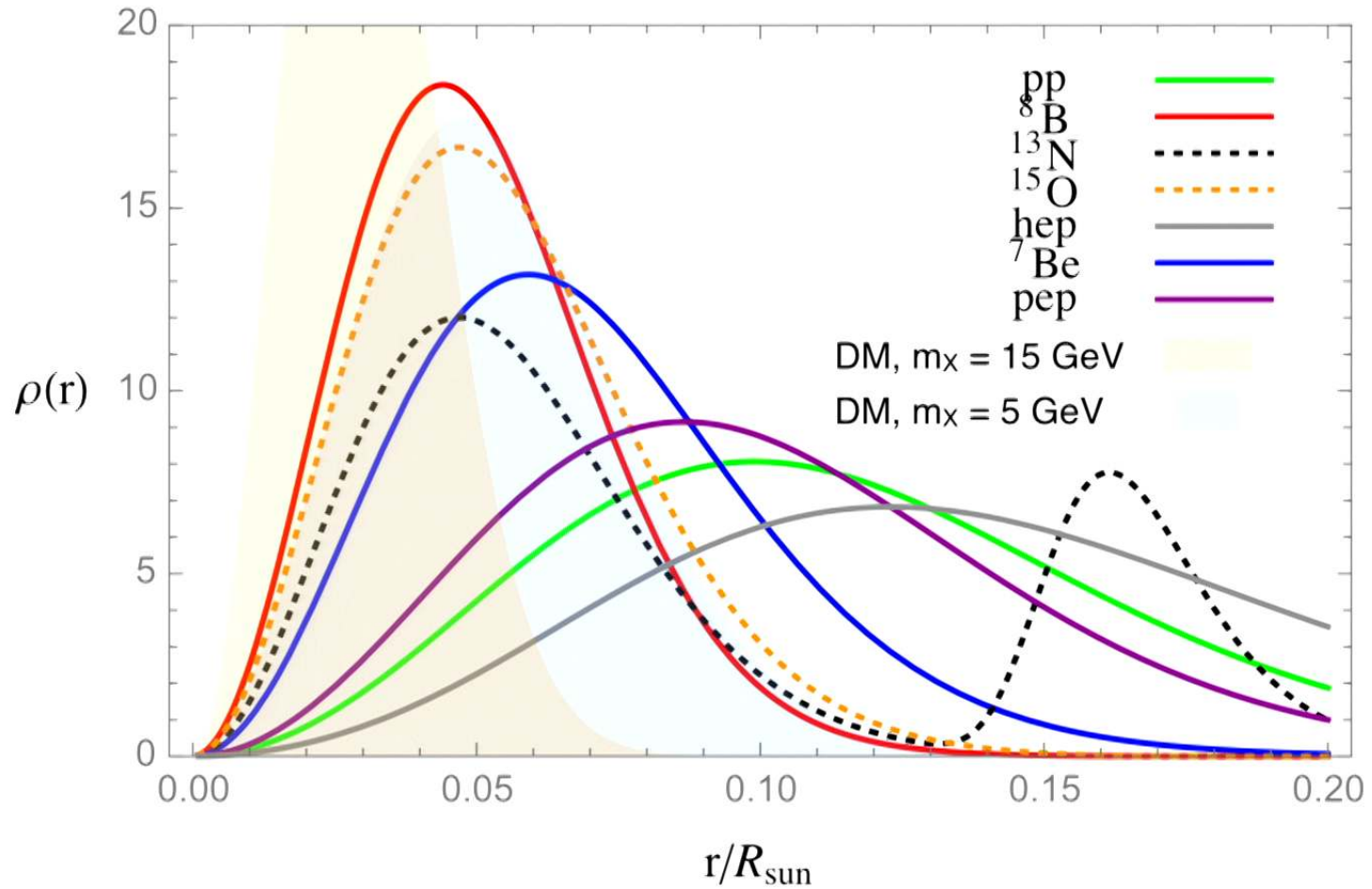
What can we probe?



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DM in the Sun: radial distribution



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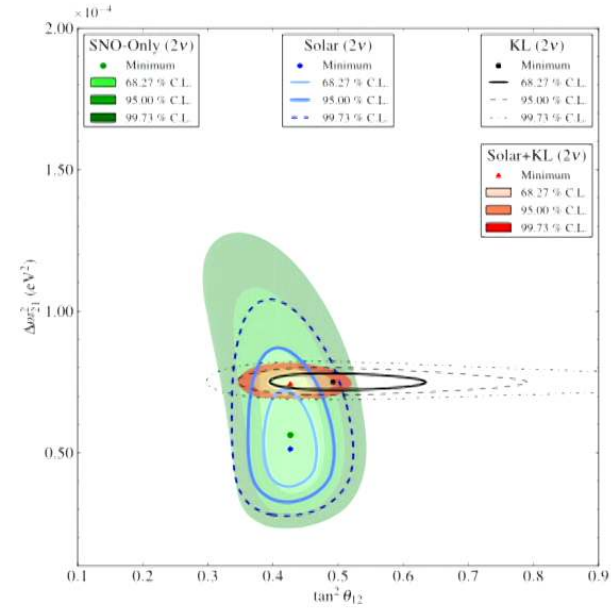
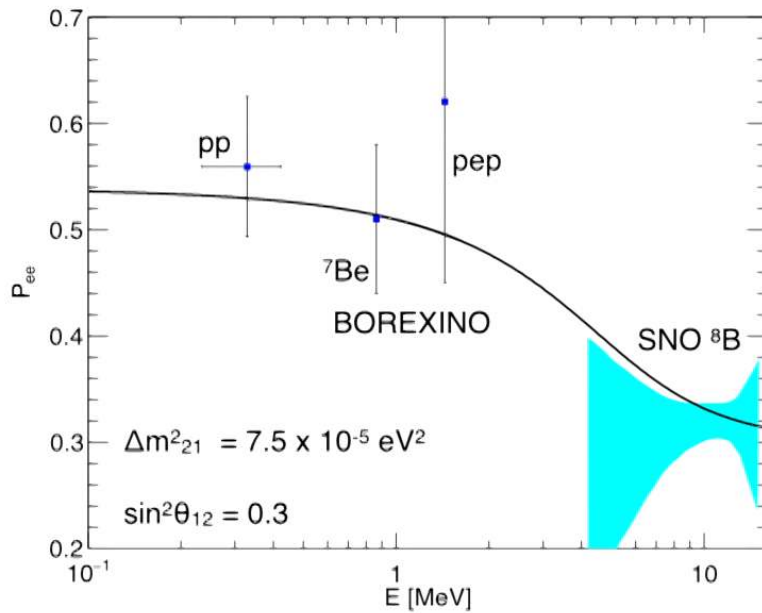
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THE POWER OF SOLAR NEUTRINOS

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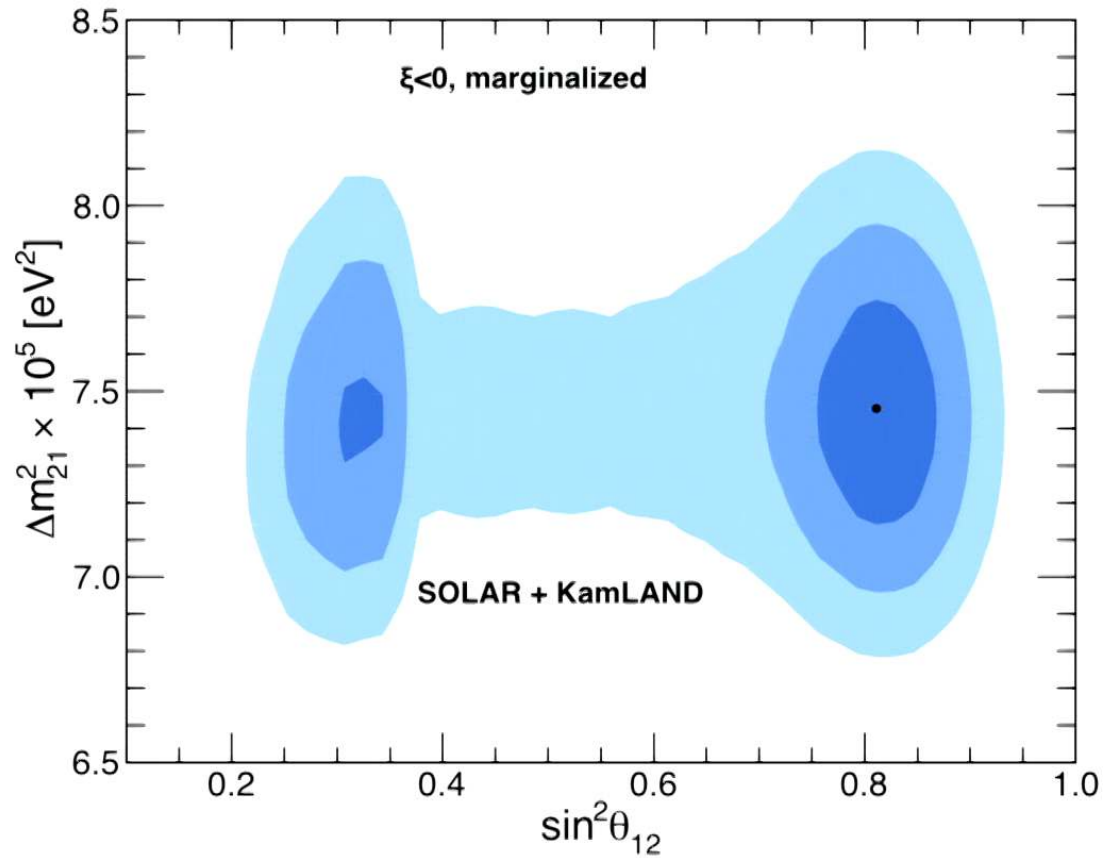
Neutrino oscillations: standard case



$$\xi \equiv \frac{G_X n_X(0)}{\sqrt{2} G_F n_e(0)}$$

Constraints from solar neutrinos

$\sin^2\theta_{12} > 0.5$ allowed and degenerate with standard solution $\sin^2\theta_{12} \sim 0.3$

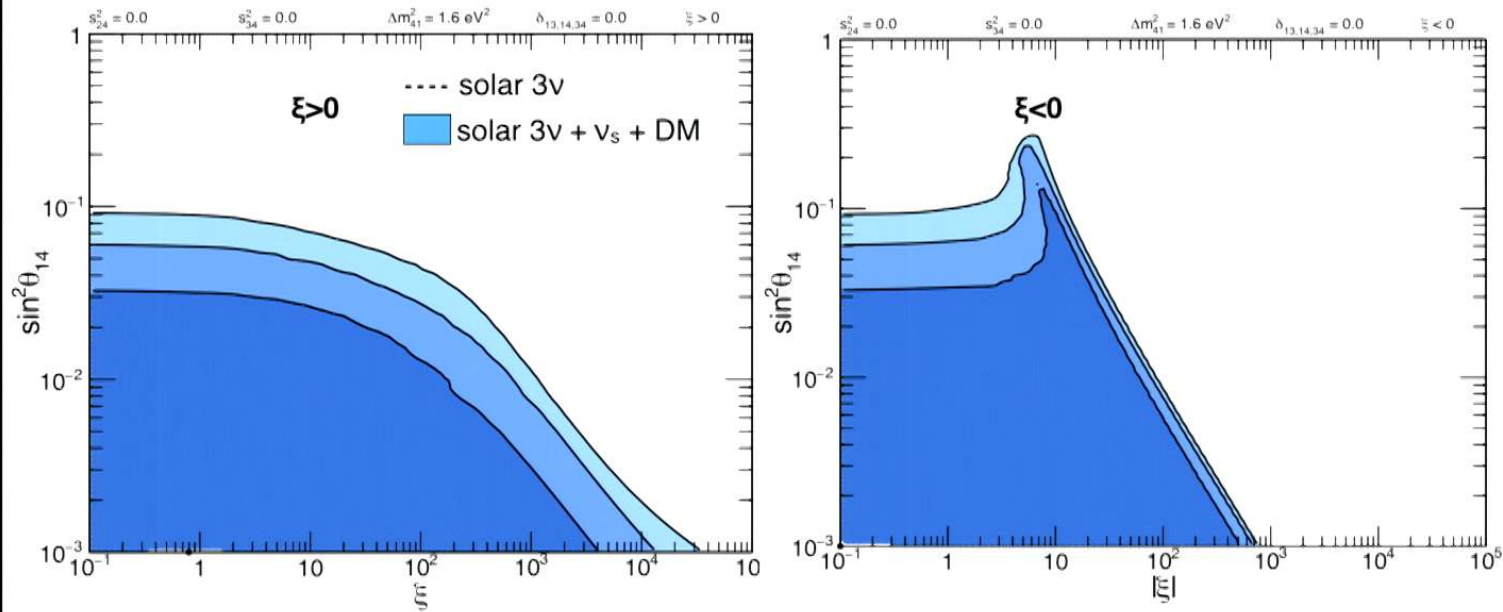


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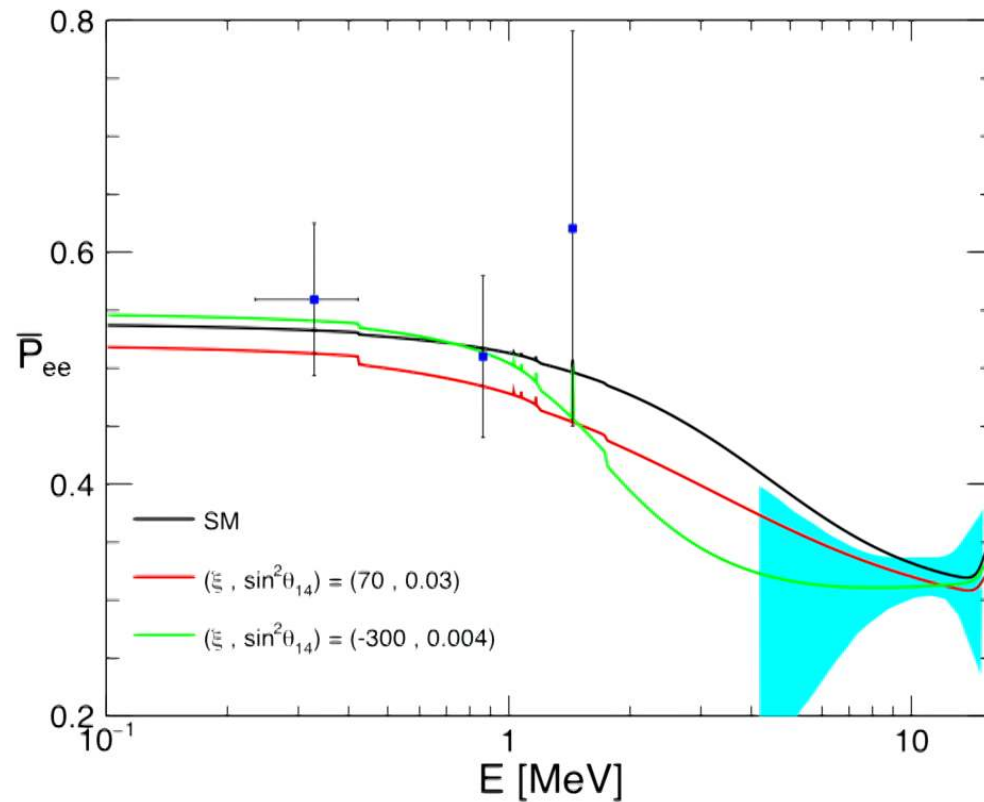
Constraints from solar neutrinos

$$\sin^2\theta_{14} |\xi| < O(10) \text{ if } \theta_{24}=0$$



Constraints from solar neutrinos

$$\bar{P}_{ee}(E) = \int dr P_{ee,\text{day}}(r, E) \frac{\sum_i \phi_i(E) \rho_i(r)}{\sum_i \phi_i(E)}$$



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Conclusions

- The **Sun might be a probe of neutrino-DM interactions**
- Effect on ^8B , ^7Be , and **CNO neutrinos**
- $|\xi| \sin^2\theta_{14} < O(10)$
- Similarly to NSI, a **Dark-LMA solution** is mildly favored for $\xi < 0$
- Future measurement on **CNO ν** needed