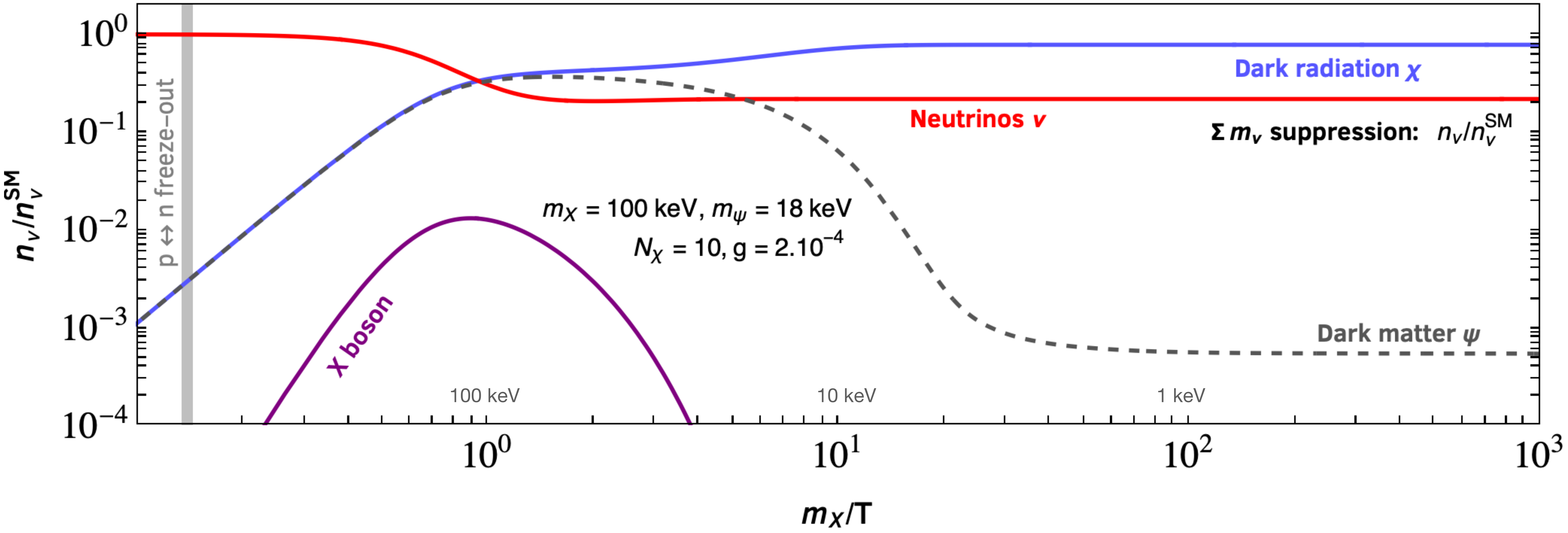
LARGE NEUTRINO MASSES CONSISTENT WITH COSMOLOGY & keV STERILE NEUTRINO DARK MATTER FROM A DARK SECTOR

Cristina Benso, KIT

Based on [2410.23926 [hep-ph]] in collaboration with Thomas Schwetz and Drona Vatsyayan



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- Is it possible that the same dark sector that could make laboratory measurement compatible with cosmological limits can also provide a viable dark matter candidate?

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⟶ the transformation of ν into χ must take place in the specific temperature range $100 \text{ keV} \gtrsim T \gtrsim 10$ eV.

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Bonus:

- one lighter copy N' of the heavy RH Majorana neutrinos N, participating in a second seesaw mechanism to give mass to ψ

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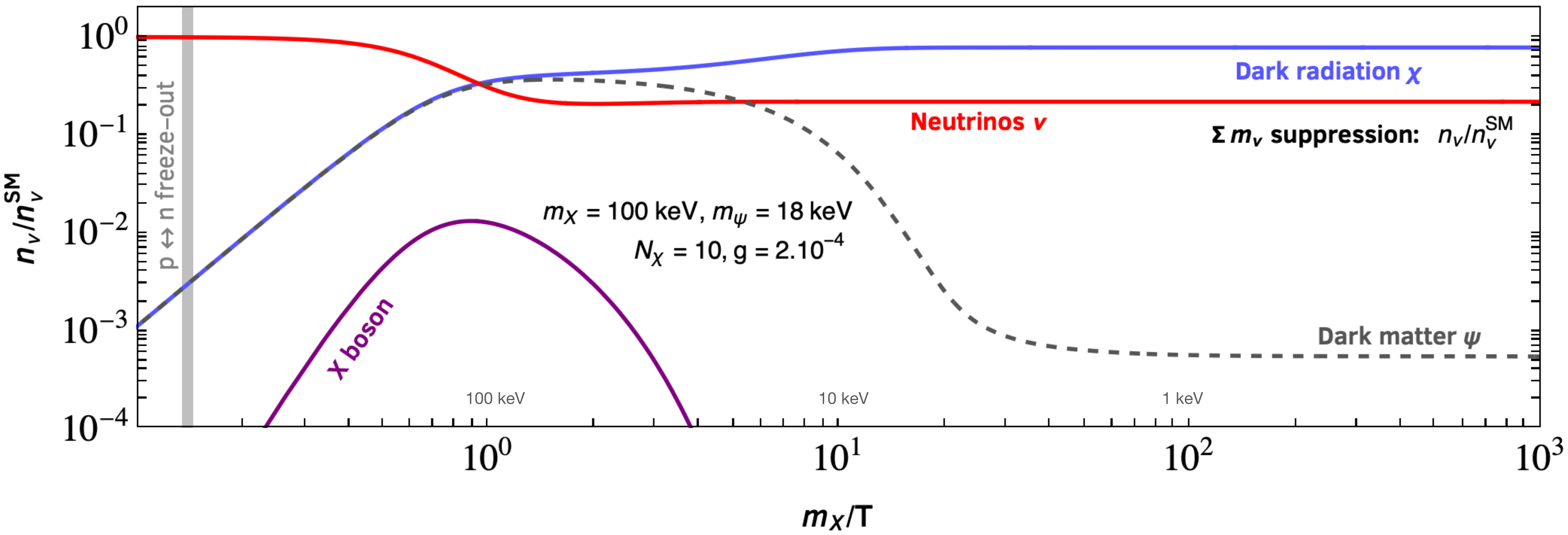
CB, T. Schwetz, D. Vatsyayan, [2410.23926 [hep-ph]]



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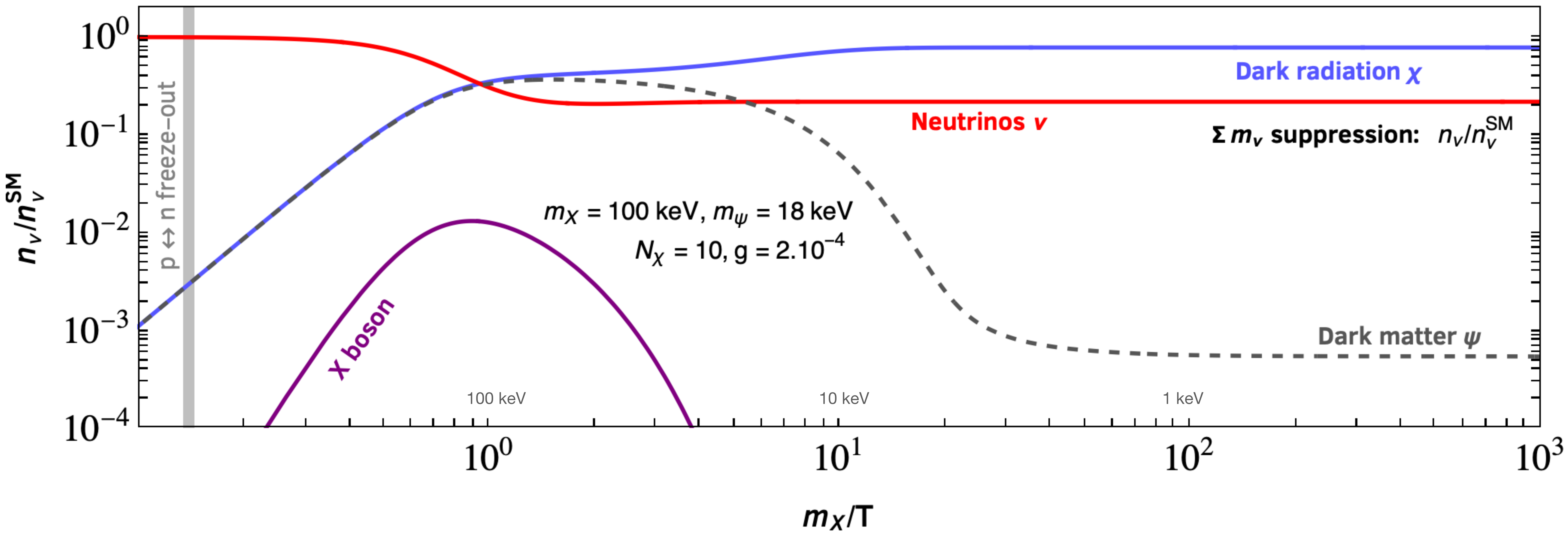

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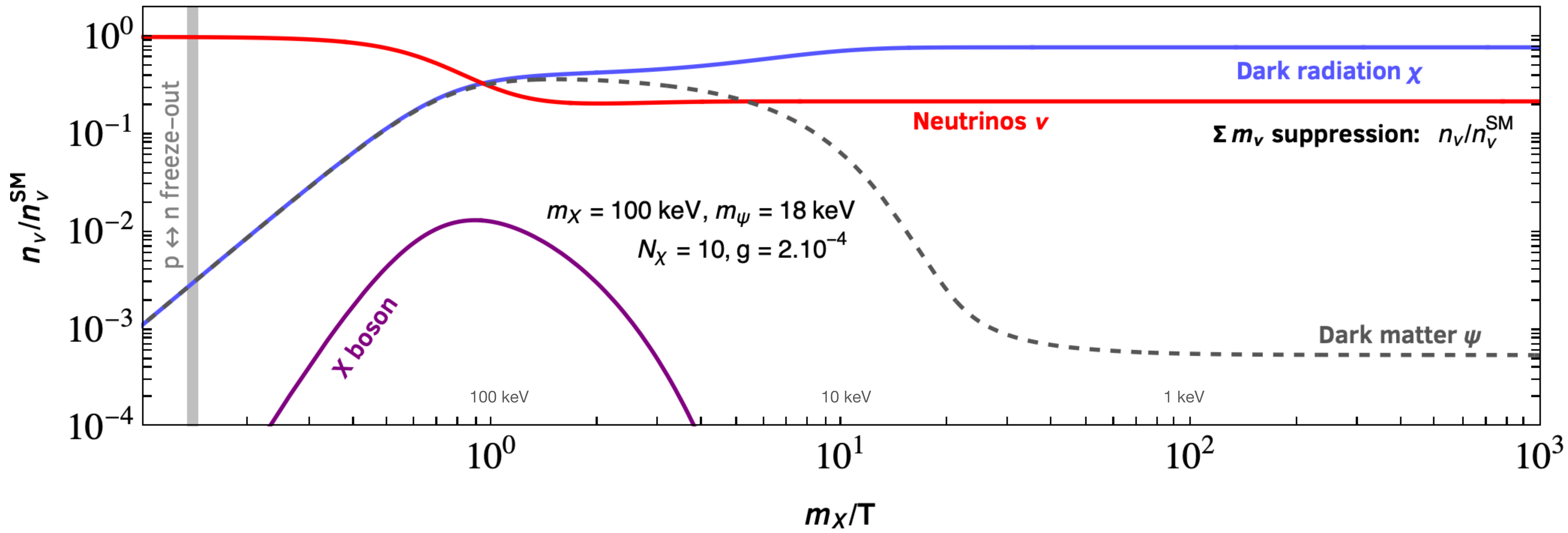

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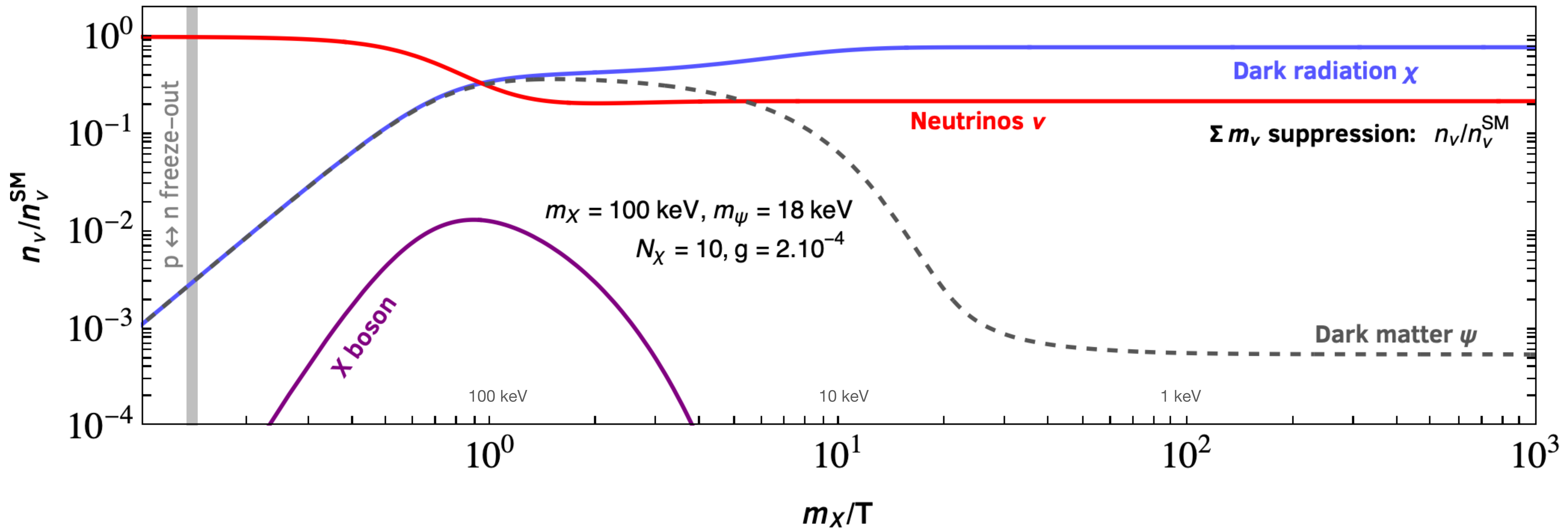

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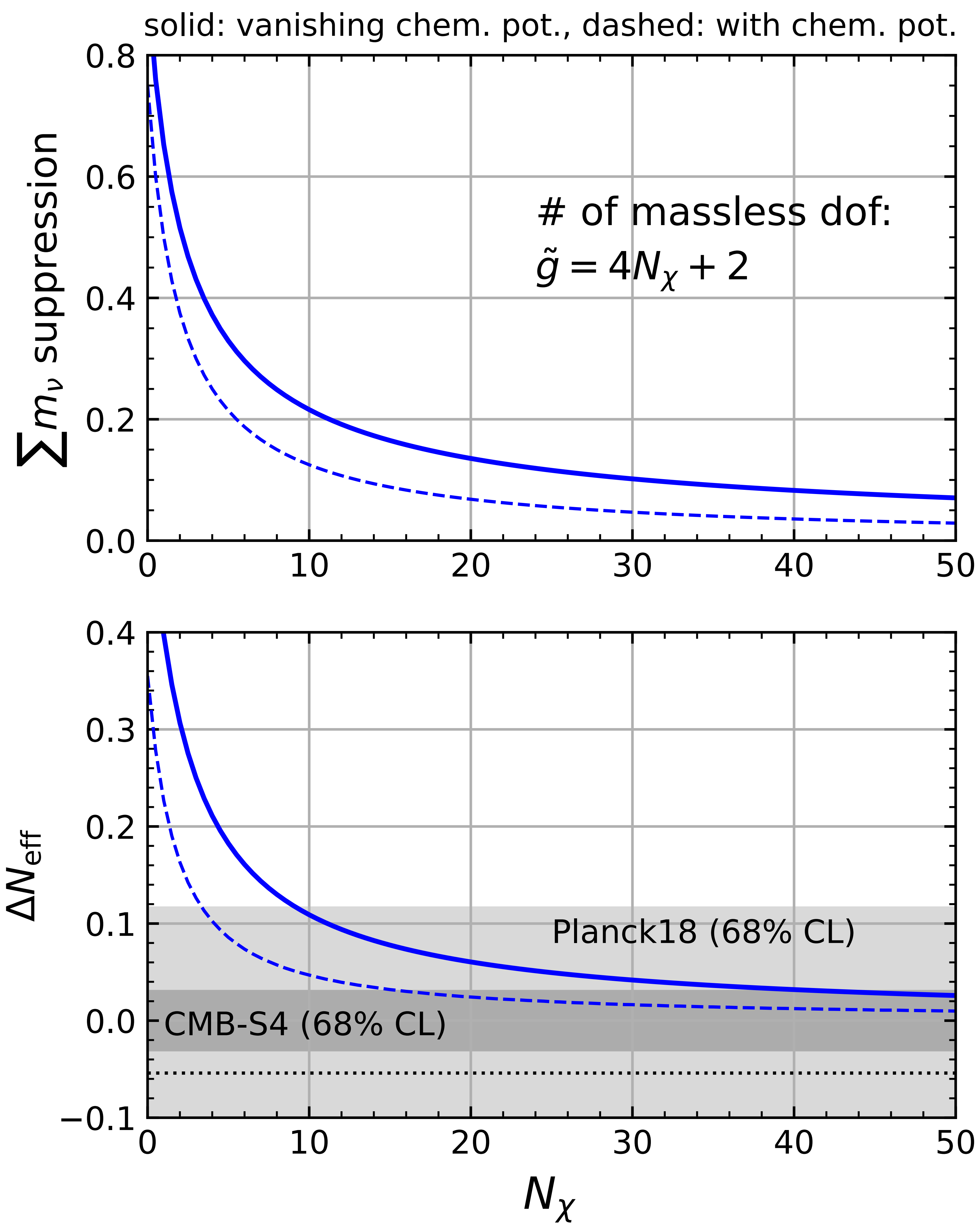
- *At late times,* DM freezes-out via annihilations $\psi\psi \rightarrow \chi\chi$ (possibly avoiding DM overproduction)

PREDICTIONS



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Suppression of cosmological bound on $\Sigma\, m_\nu$:

is the factor $\left(\frac{n_\nu}{n_\nu^{SM}}\right) < 1$ by which the limit on $\Sigma\, m_\nu$ is relaxed in

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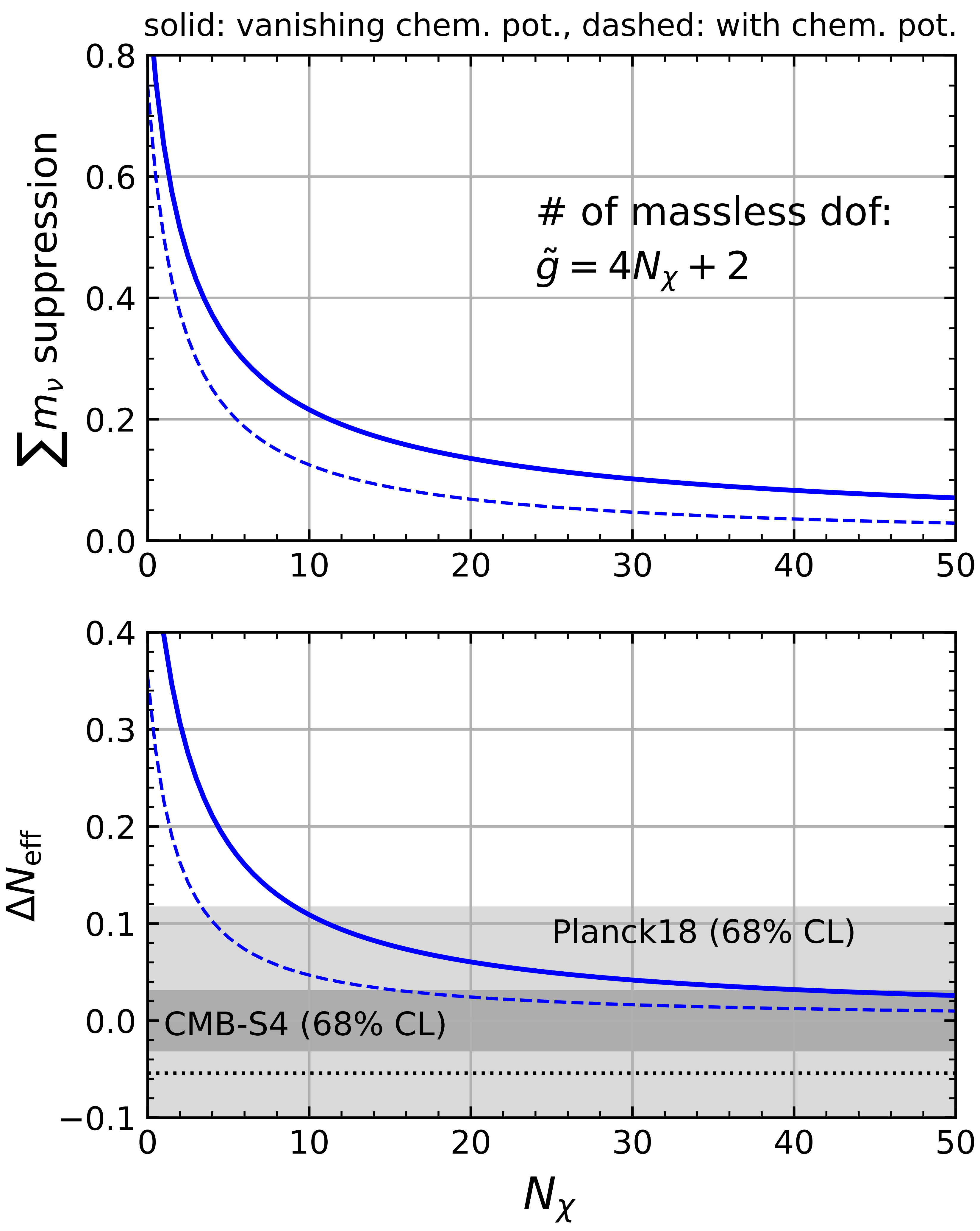

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Deviation from standard value of effective number of neutrino species :

$$\Delta N_{eff} = \frac{8}{7}\left(\frac{11}{4}\right)^{4/3}\frac{\rho_{dark}}{\rho_\gamma} = \frac{g_\nu + \tilde{g}}{2}\left(\frac{T_{dark}}{T_\nu^{SM}}\right)^4 =$$

$$= \frac{g_\nu}{2}\frac{(g_\nu + \tilde{g} + g_\psi + \frac{8}{7}g_{Z'})^{1/3}}{(g_\nu + \tilde{g})^{1/3}}$$

CONCLUSIONS

- We considered an extension of the SM neutrino sector, by addition of
  - 4 copies of heavy RH neutrinos, N and N', that participate in two separate seesaw mechanisms,
  - 1 sterile neutrino DM candidate ψ,
  - N_χ families of massless dark fermions χ,
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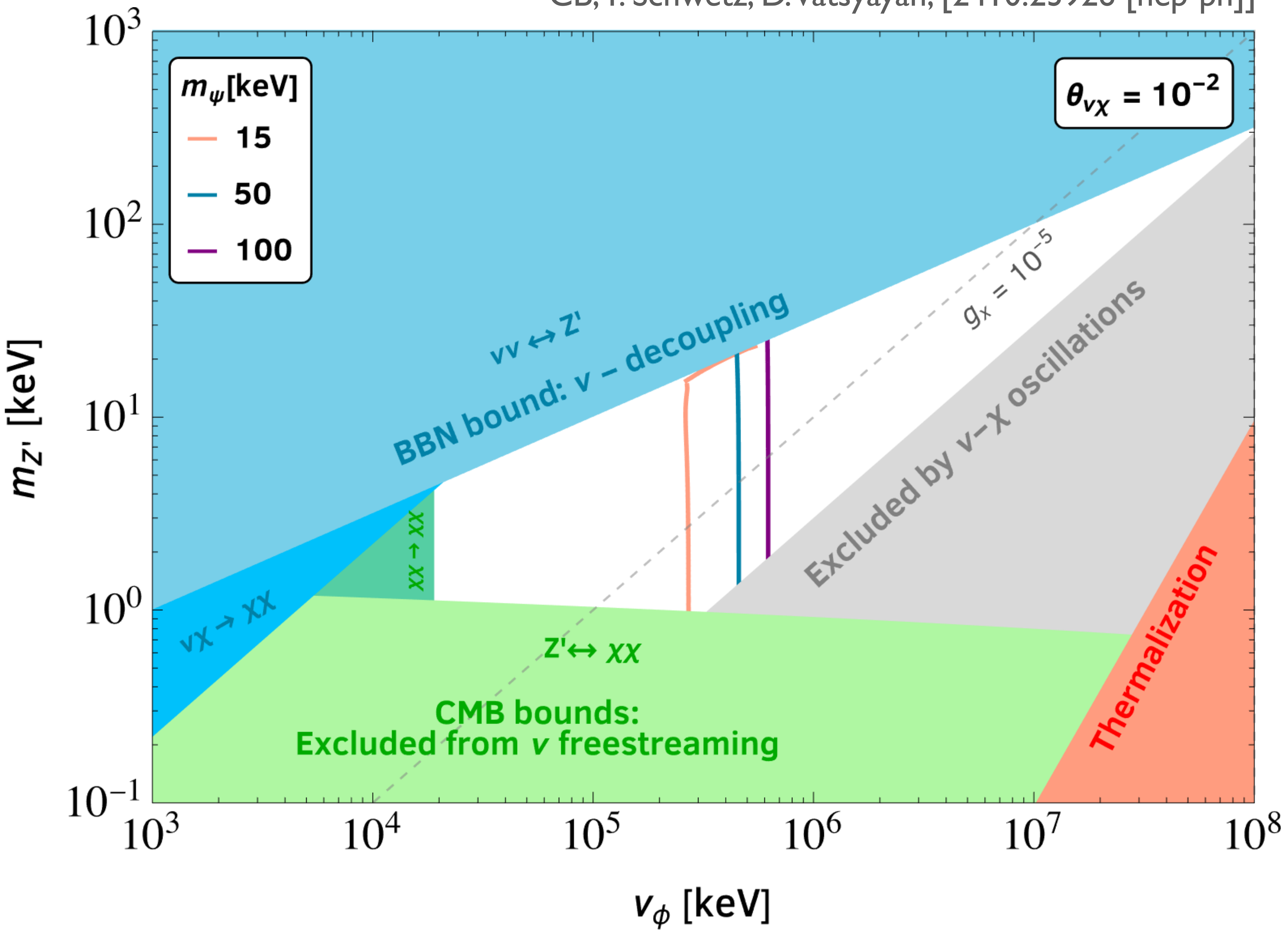
- Our model predicts a sizable deviation of N_{eff} from the SM value at recombination, that may be observable by future CMB missions.

BACKUP SLIDES

CB, T. Schwetz, D. Vatsyayan, [2410.23926 [hep-ph]]



Remember:
Relevant parameters for phenomenology
$\{m_\psi, m_{Z'}, v_\phi, \theta_{\nu\chi}, N_\chi\}$

here $N_\chi = 10$

CONSTRAINTS AND PREDICTIONS

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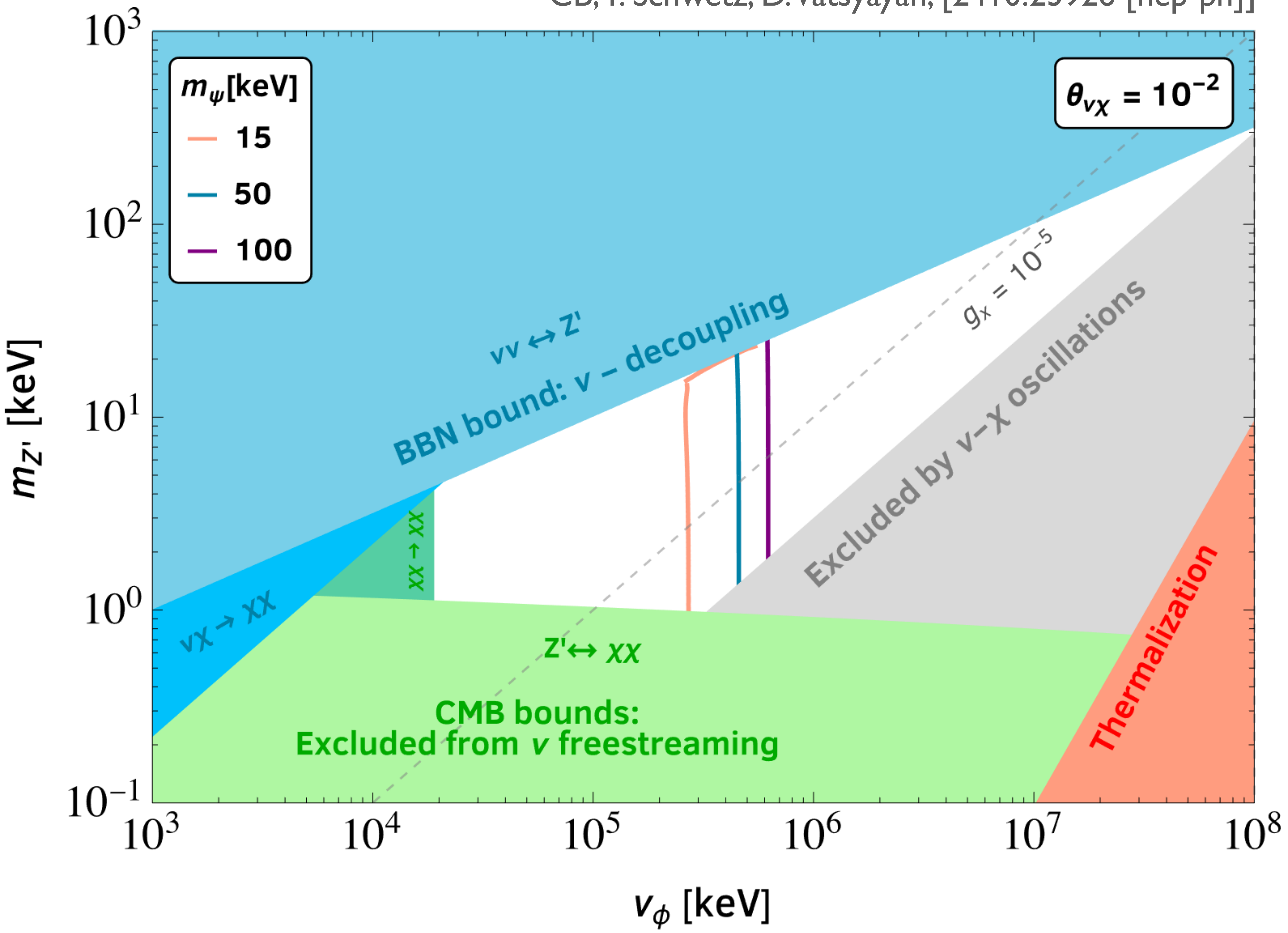

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Majority of constraints from requirement of equilibrium or non-equilibrium of various processes within the dark sector or involving also active neutrinos

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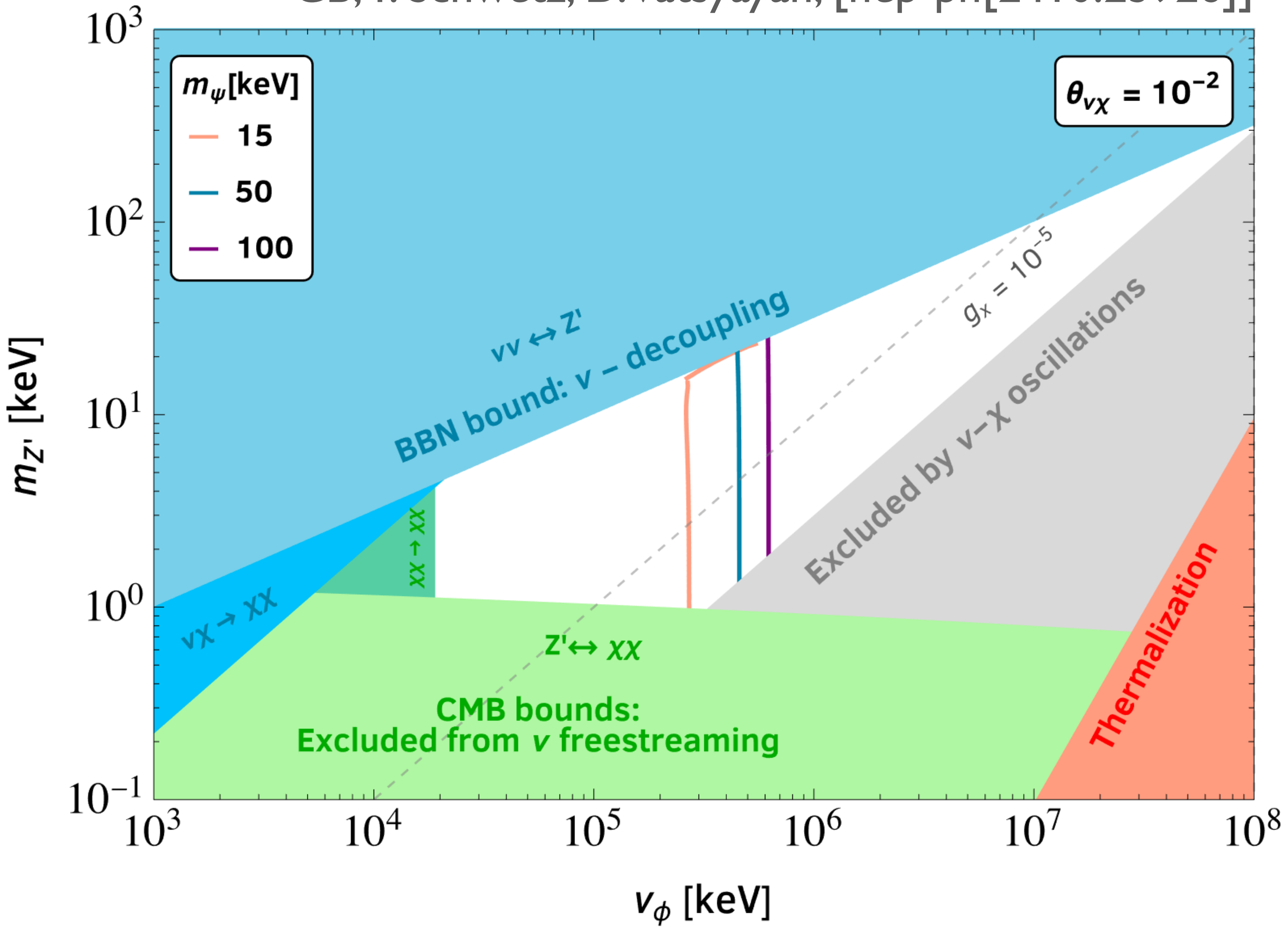

Thermalization:

- ν must thermalise with Z' in the interval 100 keV > T > 10 eV

⟶ condition: $\langle \Gamma(Z' \leftrightarrow \nu\nu) \rangle > H(T \sim m_{Z'}/3)$;

BBN:

- ν should not be in thermal equilibrium with Z' at T > 0.7 MeV

⟶ condition: $\langle \Gamma(Z' \leftrightarrow \nu\nu) \rangle < H(T = 0.7 \text{ MeV})$;

- an existing abundance of χ must not grow exponentially before BBN

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CMB:

- CMB must not be distorted by $\nu\nu \leftrightarrow Z'$ and $Z' \leftrightarrow \chi\chi$ at $z < 10^5$

⟶ $\langle \Gamma(\nu\nu \leftrightarrow Z') \rangle < H(T = 23 \text{ eV})$ and $\langle \Gamma(Z' \leftrightarrow \chi\chi) \rangle < H(T = 23 \text{ eV})$;

- CMB must not be perturbed by χ free-streaming at $z < 10^5$

⟶ $\langle \Gamma(\chi\chi \leftrightarrow \chi\chi) \rangle < H(T = 23 \text{ eV})$

ΔN_{eff} due to $\nu - \chi$ oscillations:

- Production of χ via oscillations contributing to ΔN_{eff} must be small

$$\longrightarrow \Delta N_{eff} \simeq 0.014 \sum_{\chi=1}^{N_\chi} \frac{|\theta_{e\chi}|^2 + 0.8(|\theta_{\mu\chi}|^2 + |\theta_{\tau\chi}|^2)}{10^{-6}} \left(\frac{m_\nu}{0.1\text{eV}} \right) < 0.3 \,.$$

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INTRODUCTION & MOTIVATIONS

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  - active neutrino masses ⟶ seesaw mechanism (3 heavy RH Majorana neutrinos N)
  - dark matter ⟶ sterile neutrino DM (ψ)

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- Is it possible that the same dark sector that makes laboratory measurement compatible with cosmological limits provides also a viable dark matter candidate?

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