Invisible Higgs decay from dark matter freeze-in at stronger coupling

Based on: JHEP 04 (2025) 136

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Motivation

- **Low Reheating Temperature Scenarios**
- **Invisible Higgs Decay Window**

Set-up

Interactions

We assume the minimal Higgs portal set-up with singlet dark matter of spin 0. The effective interactions is given by

$$\mathscr{L}^{s}_{\text{eff}} = \frac{\lambda_{hs} m_f}{2m_h^2} \bar{f} f S S \tag{1}$$

Main contributions

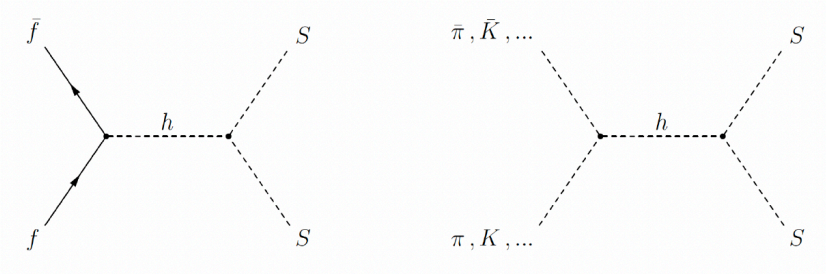
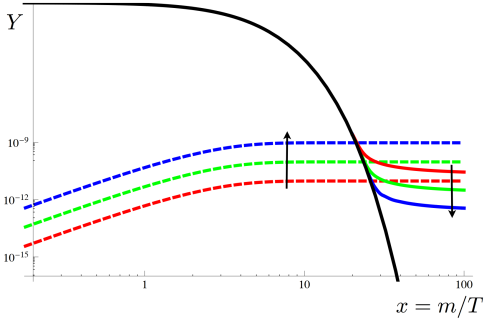


Figure 1: Main contributions to dark matter production at low temperatures.

Standard Freeze-in

- In the freeze-in, the DM is out of equilibrium

$$\Gamma < H. \tag{2}$$

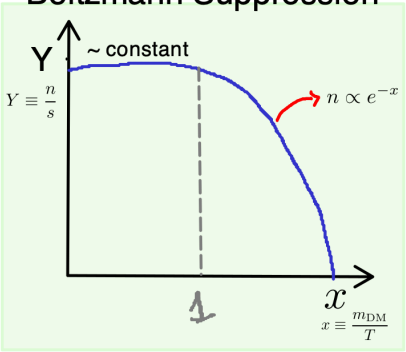


Strong Freeze-in

Assumption

$$m_{\rm DM} > T_R$$

Boltzmann Suppression



Freeze-in Criteria

$$e^{-\frac{m}{T}}\lambda^2 < \frac{T^2}{M_{Pl}}$$

$\sim 10^{-8}$

$$\lambda \sim 10^{-1}\ \text{GeV}^{-2}$$

Summary

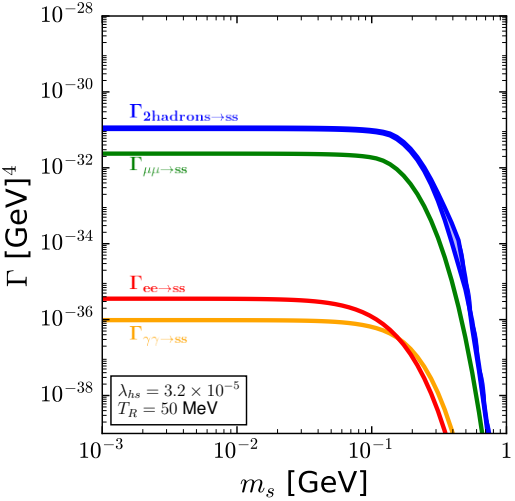
Standard Freeze-in

- $\Gamma_\chi < H$
- $m_{\rm DM} \ll T_R$
- $n \propto T^3$
- Small coupling ($\lambda \lesssim 10^{-10}$)
- Hard to probe

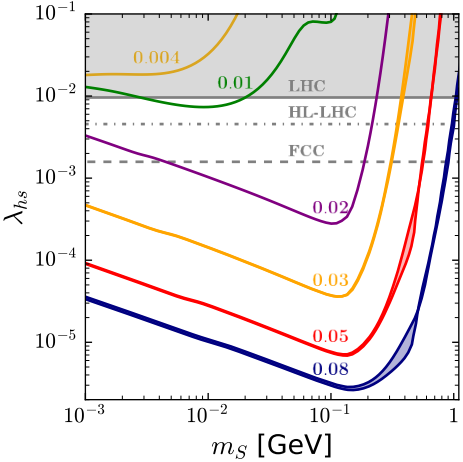
Strong Freeze-in

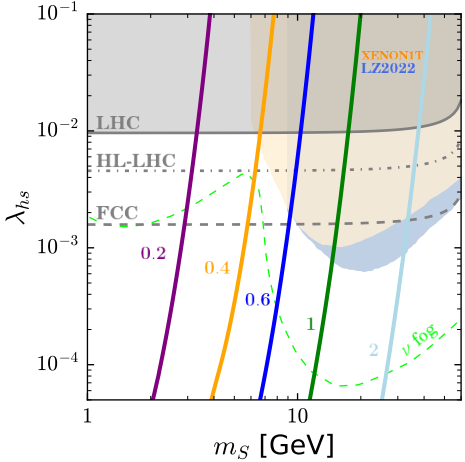
- $\Gamma_\chi < H$
- $m_{\rm DM} \gg T_R$
- $n \propto e^{-m/T}$
- Strong coupling ($\lambda \sim 10^{-1}$)
- Easy to probe

Results


10^{-28}
10^{-30}
10^{-32}
10^{-34}
10^{-36}
10^{-38}
Γ [GeV]^4
$\Gamma_{2\text{hadrons}\to ss}$
$\Gamma_{\mu\mu\to ss}$
$\Gamma_{ee\to ss}$
$\Gamma_{\gamma\gamma\to ss}$
$\lambda_{hs} = 3.2 \times 10^{-5}$
$T_R = 50$ MeV
10^{-3}
10^{-2}
10^{-1}
1
m_s [GeV]

Results


10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
λ_{hs}
0.004
0.01
LHC
HL-LHC
FCC
0.02
0.03
0.05
0.08
10^{-3}
10^{-2}
10^{-1}
1
m_S [GeV]


10^{-1}
10^{-2}
10^{-3}
10^{-4}
λ_{hs}
XENON1T
LZ2022
LHC
HL-LHC
FCC
0.2
0.4
0.6
1
2
ν fog
1
10
m_S [GeV]

Previous Publications

- **2025** *Three decades of FCNC studies in 3-3-1 model with right-handed neutrinos: from Z'-dominance to the alignment limit.* Patricio Escalona, João Paulo Pinheiro, **Vinícius Oliveira**, A. Doff, C.A.de S. Pires; arXiv:2510.17979.
- **2025** *Type-II seesaw mechanism for Dirac neutrinos and its implications on N_{eff} and lepton flavor violation in a 3-3-1 model.* **Vinícius Oliveira**, Patricio Escalona, **Lucia Angel**, C.A. de S. Pires, Farinaldo S. Queiroz; JHEP 07 (2025) 197.
- **2025** *Invisible Higgs decay from dark matter freeze-in at stronger coupling.* Oleg Lebedev, António P. Morais, **Vinícius Oliveira**, Roman Pasechnik; JHEP 04 (2025) 136.
- **2024** *CMB constraints on inflection-point inflation with pseudoscalar dark matter.* Jamerson G. Rodrigues, **Vinícius Oliveira**, Rodrigo von Marttens, Carlos A.de S. Pires, Jailson Alcaniz; Phys.Rev.D 110 (2024) 2, 023518.
- **2024** *Exploring the viability of a pseudo-Nambu-Goldstone boson as ultralight dark matter in a mass range relevant for strong gravity applications.* António P. Morais, **Vinícius Oliveira**, António Onofre, Roman Pasechnik, Rui Santos; Phys.Rev.D 110 (2024) 3, 3.
- **2023** *Bounds on quark mixing, $M_{Z'}$ and $Z - Z'$ mixing angle from flavor changing neutral processes in a 3-3-1 model.* **Vinícius Oliveira**, C.A. de S. Pires; Phys.Lett.B 846 (2023) 138216.
- **2023** *Flavor changing neutral current processes and family discrimination in 3-3-1 models.* **Vinícius Oliveira**, C.A. de S. Pires; J.Phys.G 50 (2023) 11, 115002.
- **2022** *PandaX-4T limits on Z' mass in 3-3-1LHN model.* **Vinícius Oliveira**, C.A. de S. Pires; Phys.Rev.D 106 (2022) 1, 015031.
- **2021** *A model for mixed warm and hot right-handed neutrino dark matter.* Maíra Dutra, **Vinícius Oliveira**, C.A. de S. Pires, Farinaldo S. Queiroz; JHEP 10 (2021) 005.

Thank you for listening !

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