Radiative effects on complex scalar dark matter

Lilianna Hariasz

Simon Fraser University

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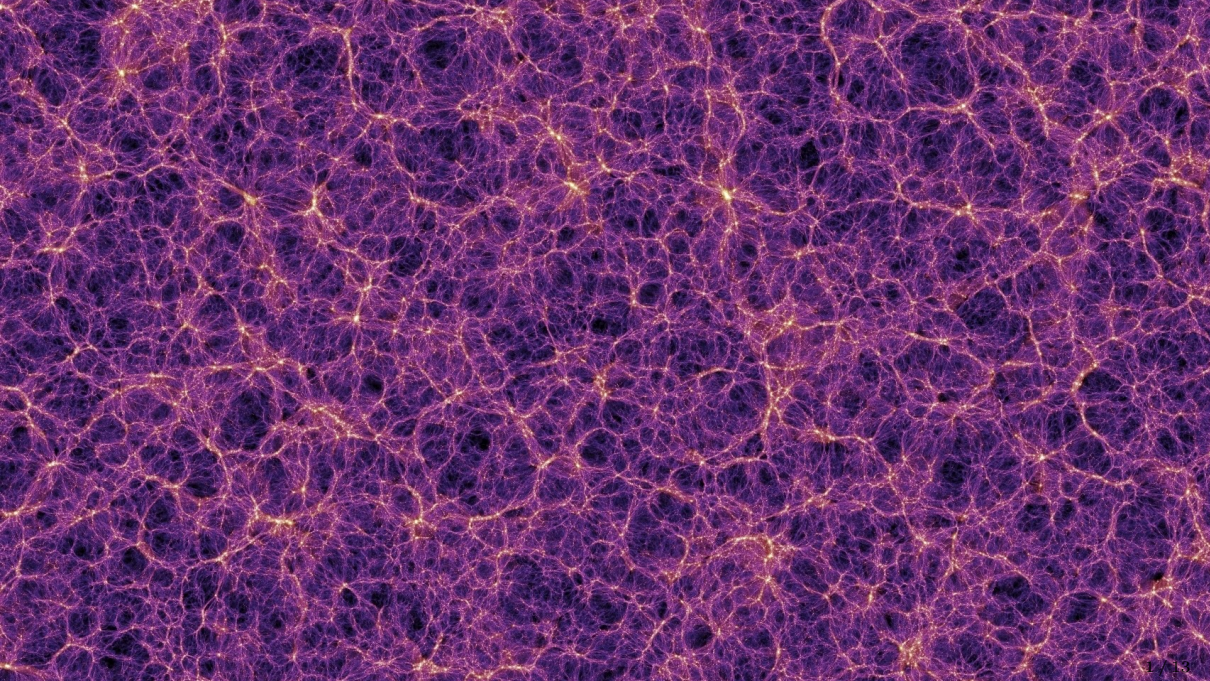
2026 CAP Congress, June 21-26, 2026, University of Ottawa



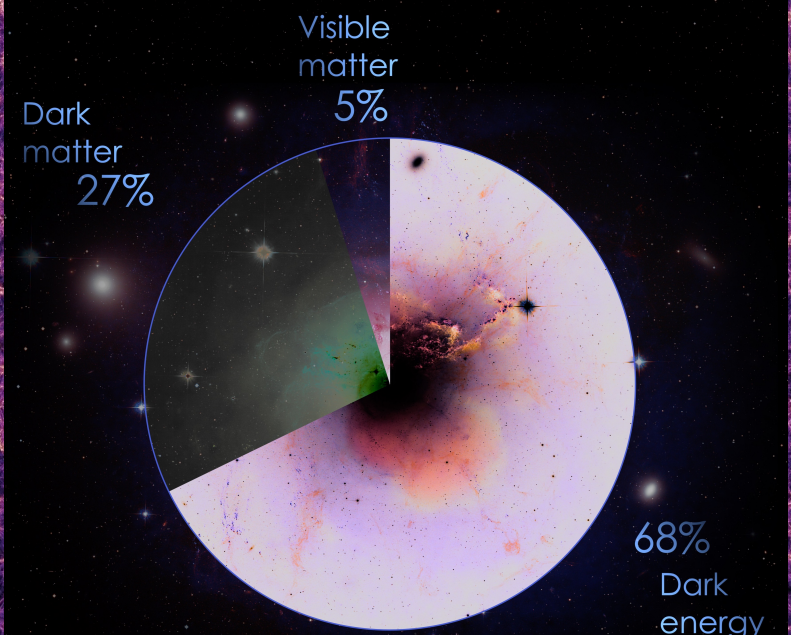
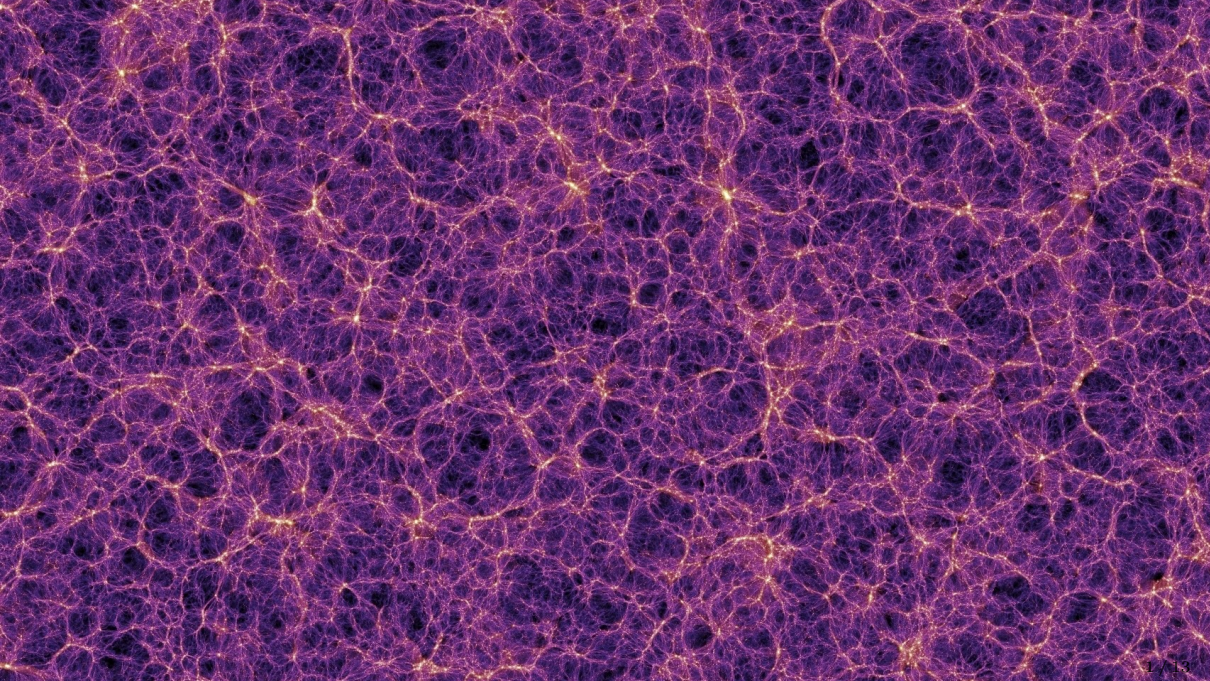
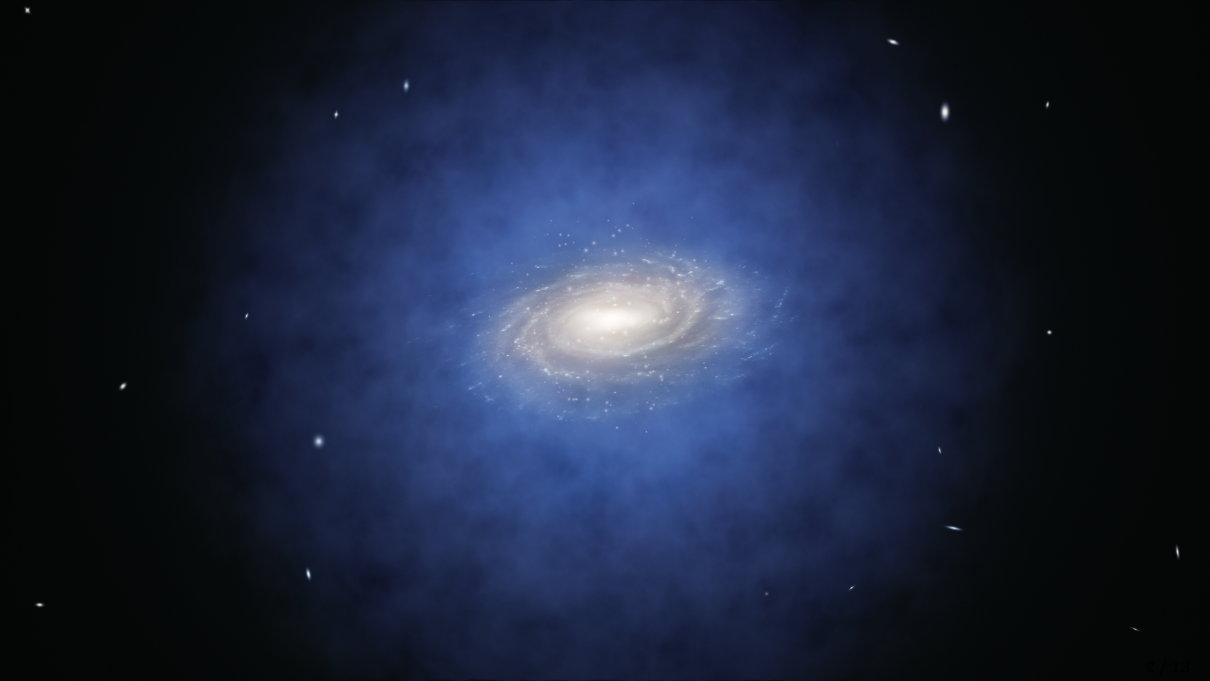


Image credits https://svs.gsfc.nasa.gov/12307; The Millenium Simulation Project





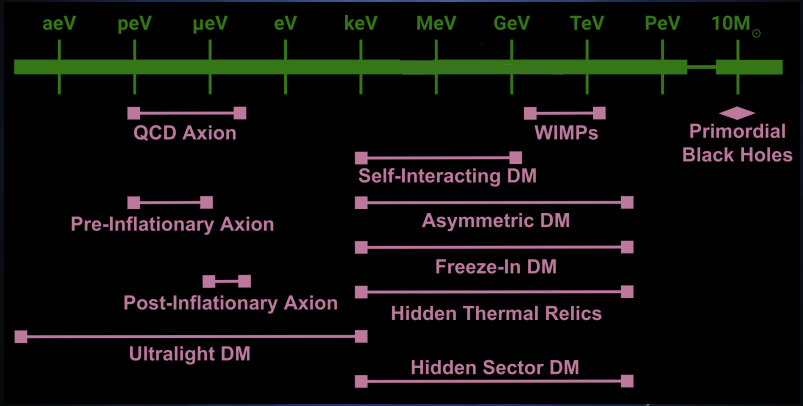
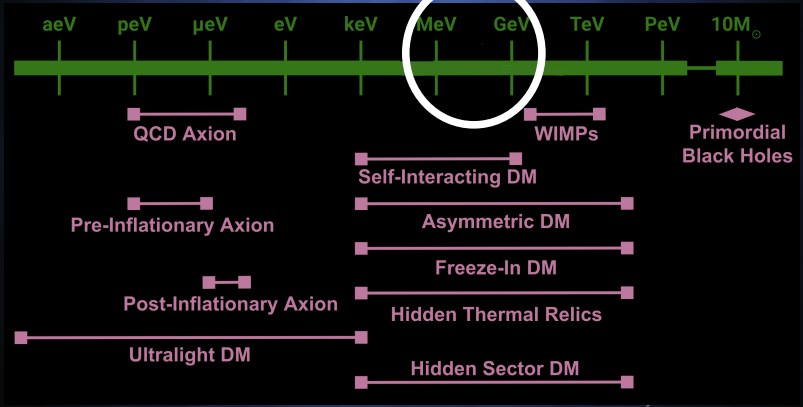


Image from https://www.hep.ucl.ac.uk/darkMatter/qs.shtml

Light Dark Matter (LDM)



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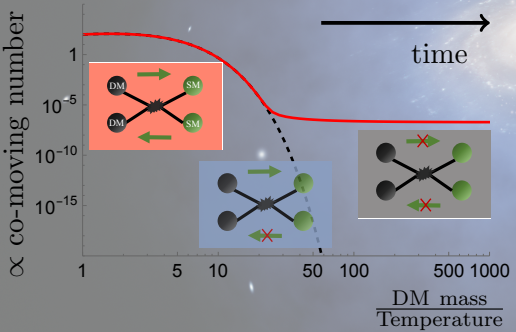
Extending the Standard WIMP Scenario

Weakly Interacting Massive Particle

- Thermal relic, one new fermion



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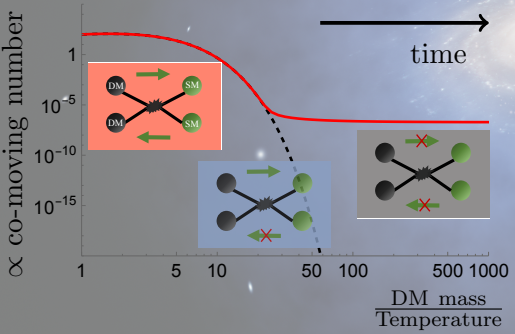

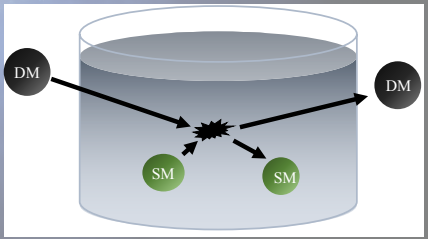

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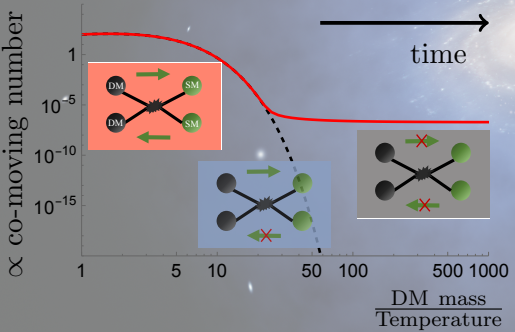
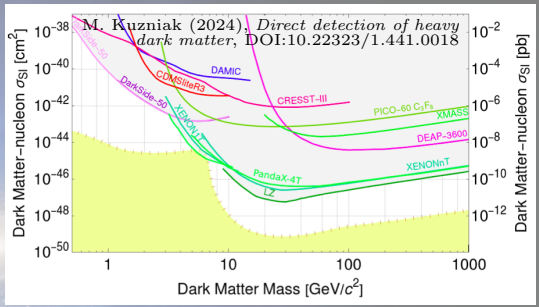
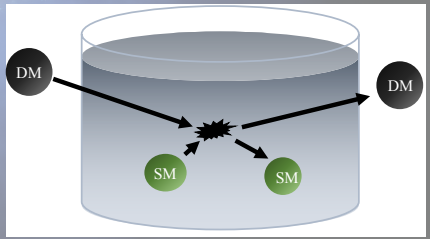
Weakly Interacting Massive Particle

- Thermal relic, one new fermion
- **Extensively studied**







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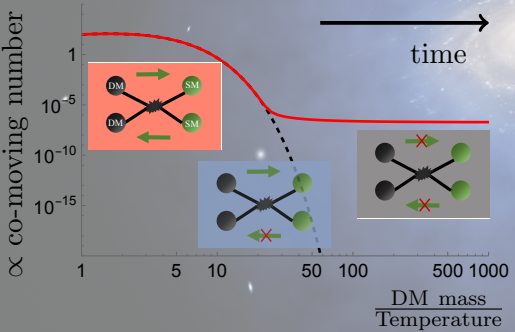

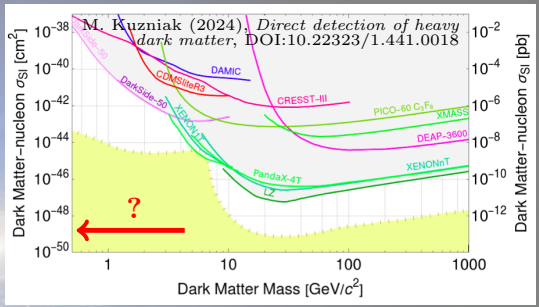

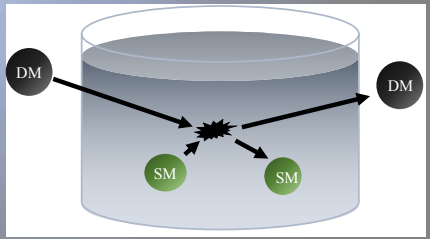

A dark sector and light dark matter

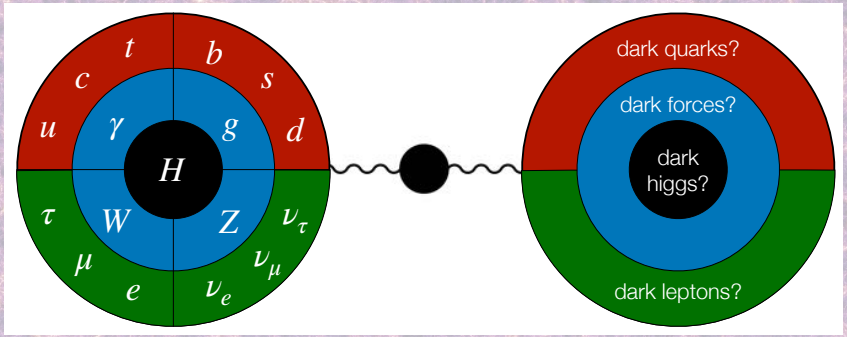

Image adapted from Gori & Williams (2022), *Dark Sector Physics at High Intensity*, arXiv:2209.04671.

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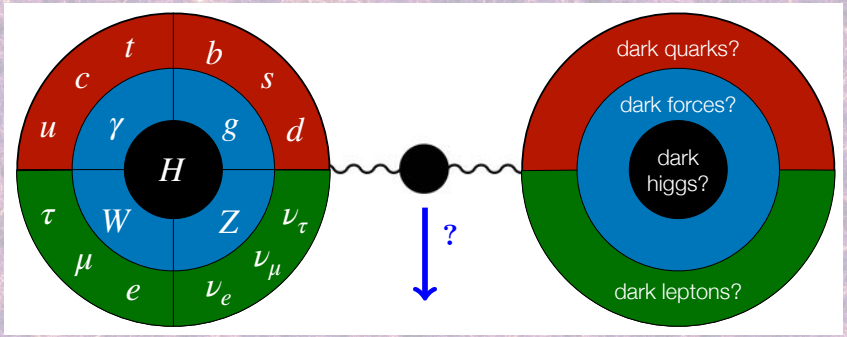
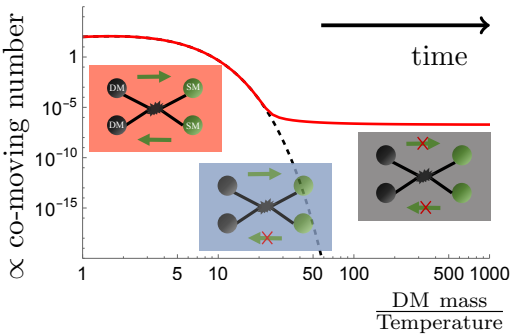


"DARK PHOTON"

Maintain freeze-out $\longrightarrow$ new experimental sub-GeV prospects

Image adapted from Gori & Williams (2022), *Dark Sector Physics at High Intensity*, arXiv:2209.04671.

sub-GeV CMB constraints

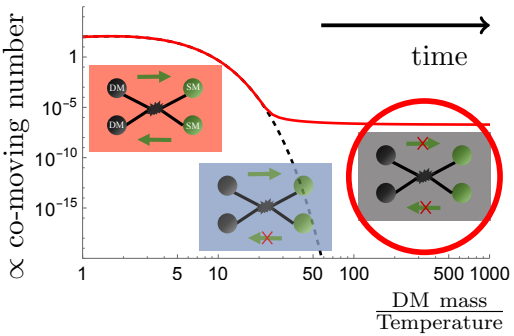


- **DM does not completely stop annihilating at freeze-out**
- sub-GeV Dirac DM $\Longrightarrow$ re-ionization of hydrogen at re-combination

Some viable alternatives

- Late-time asymmetry
- Velocity supression: **Complex scalar** $\langle \sigma_{\rm ann} v \rangle \propto v_{\rm rel}^2$

sub-GeV CMB constraints



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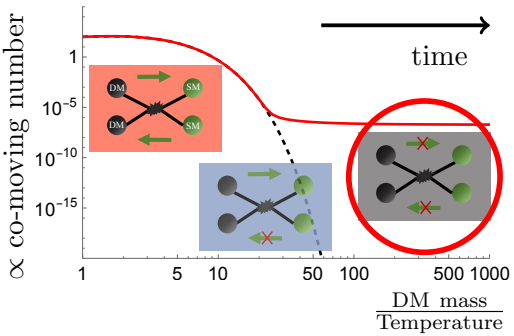

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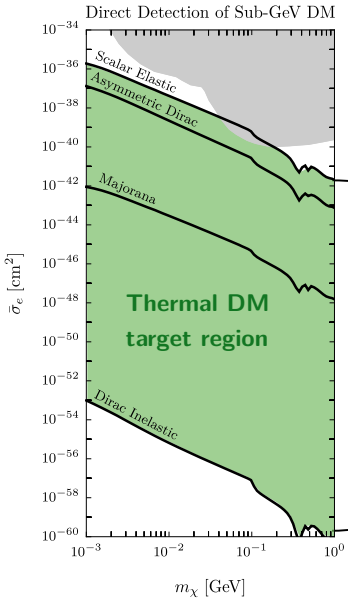
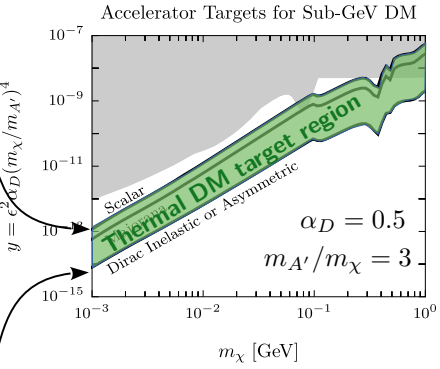
LDM thermal relics: direct detection & accelerator targets

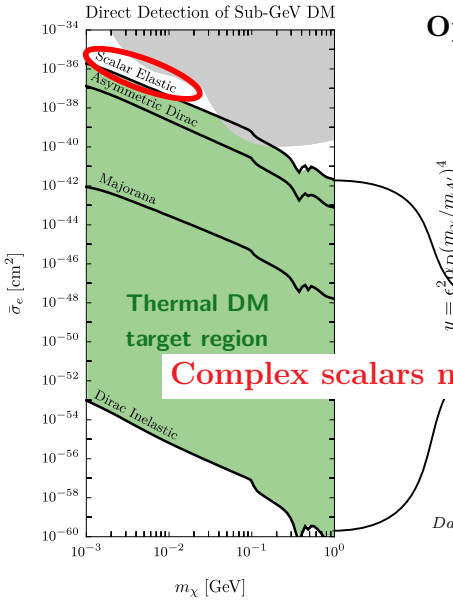


Opportunities identified at Snowmass 2021



Krnjaic et al. (2022), *A snowmass whitepaper: Dark matter production at intensity-frontier experiments.*

LDM thermal relics: direct detection & accelerator targets



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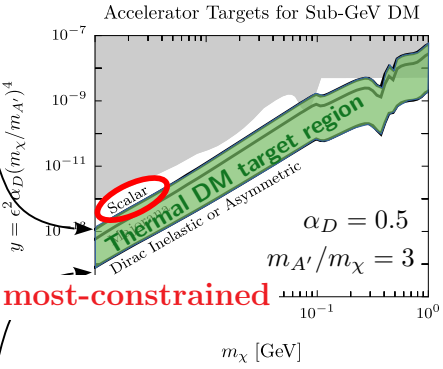
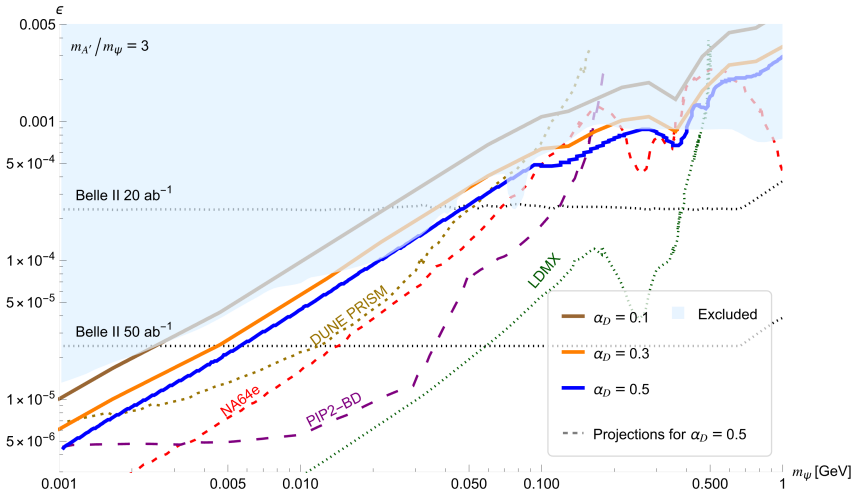


Complex scalars most-constrained

Krnjaic et al. (2022), *A snowmass whitepaper: Dark matter production at intensity-frontier experiments.*

Expected mixing strengths with the SM: complex scalars



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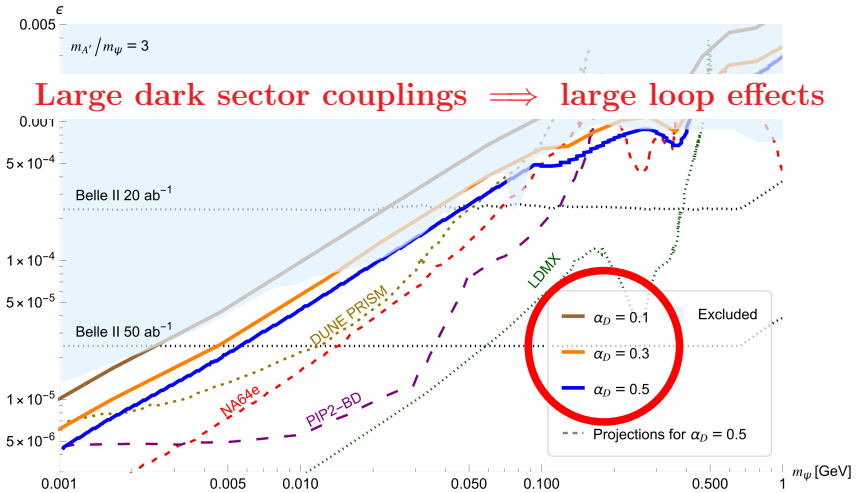

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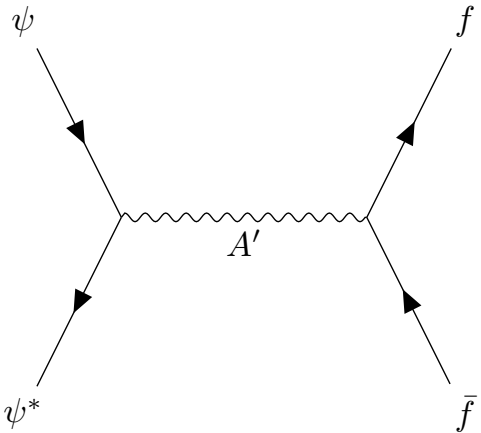
Effects at loop level



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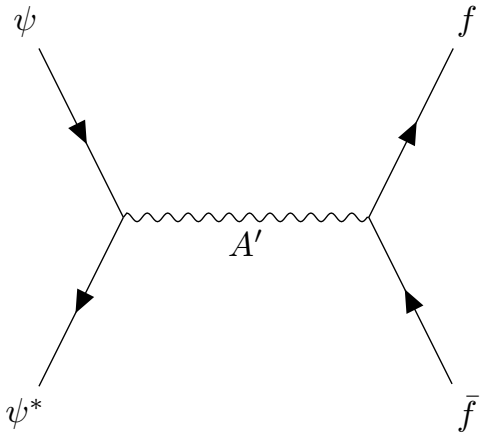

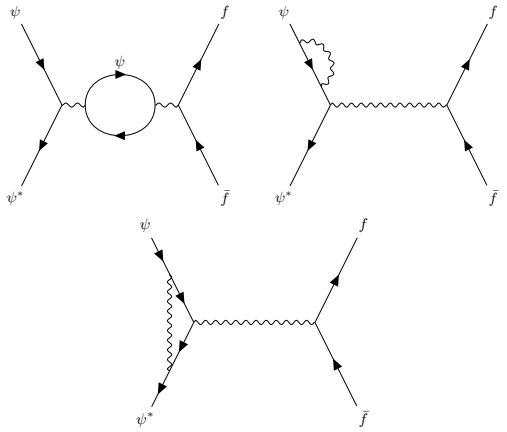

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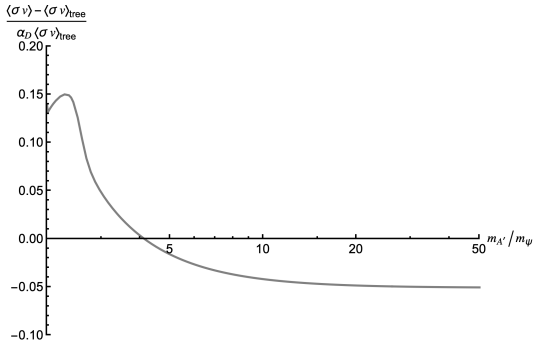
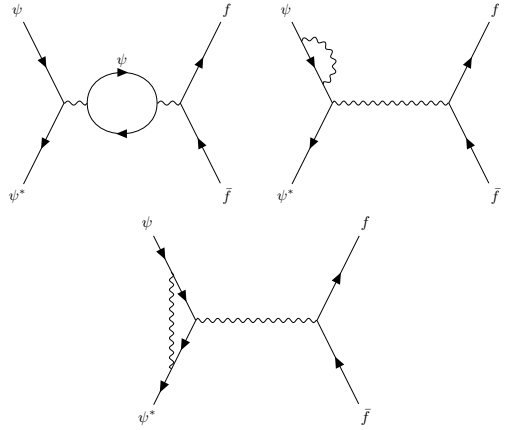
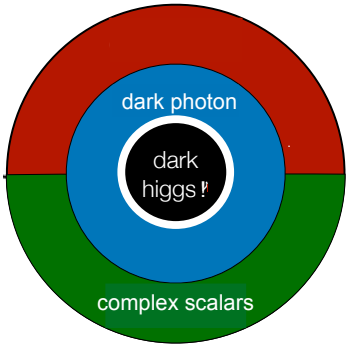




An explicit origin of the dark photon's mass



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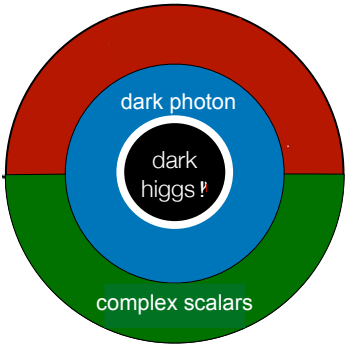

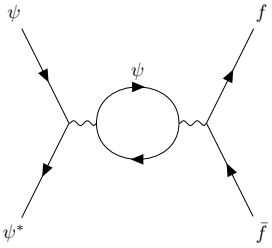

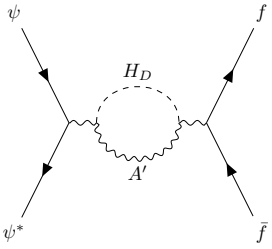

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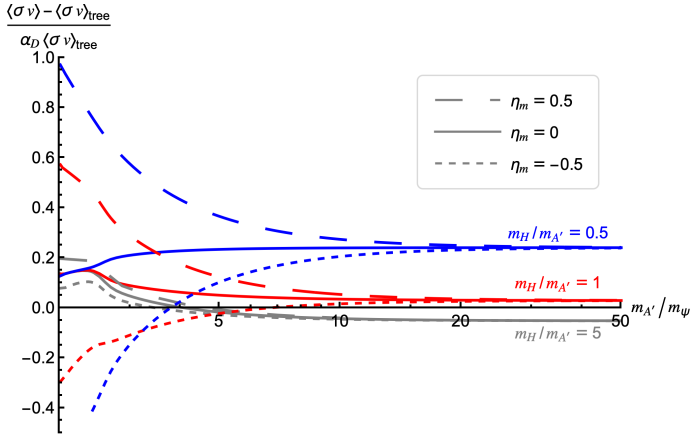
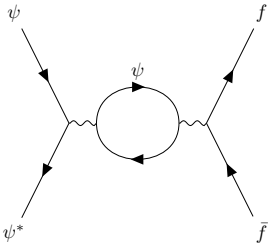
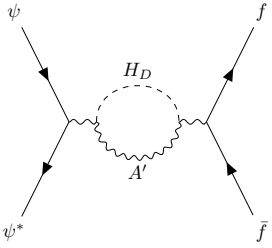
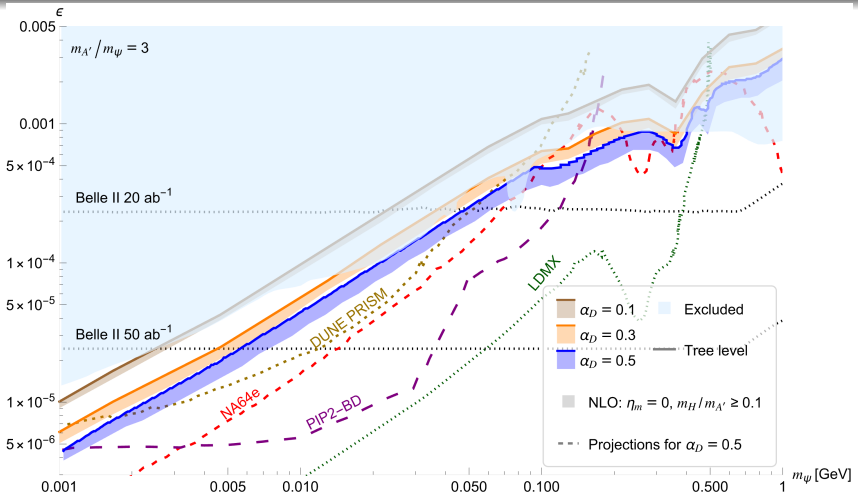






Loops & the dark Higgs



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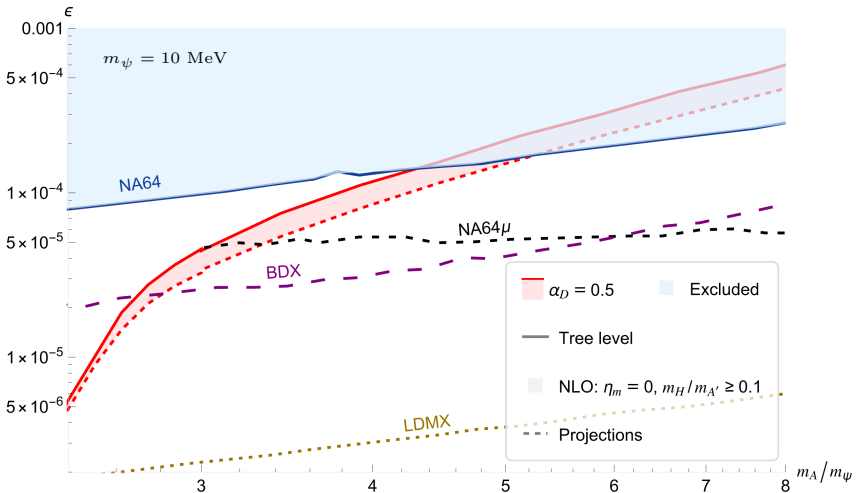

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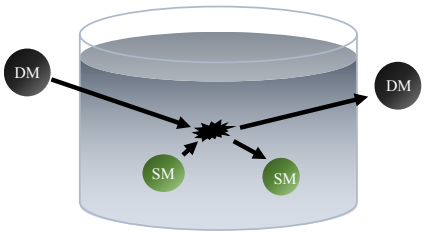
Direct detection

Reference cross-section, $\psi + e^- \to \psi + e^-$



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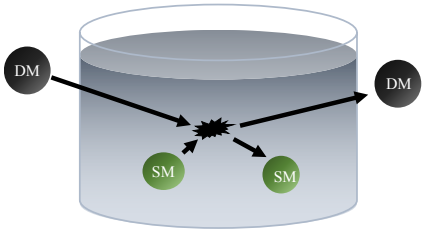

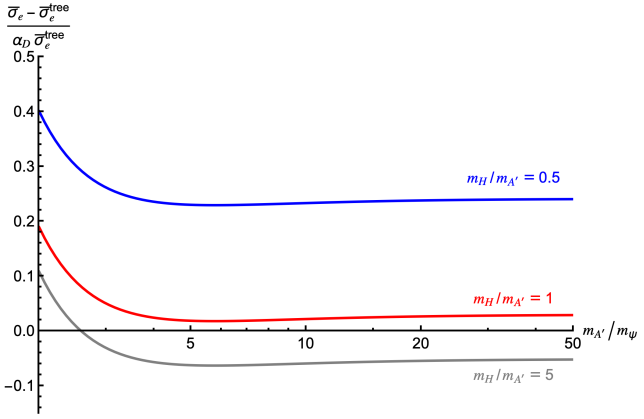

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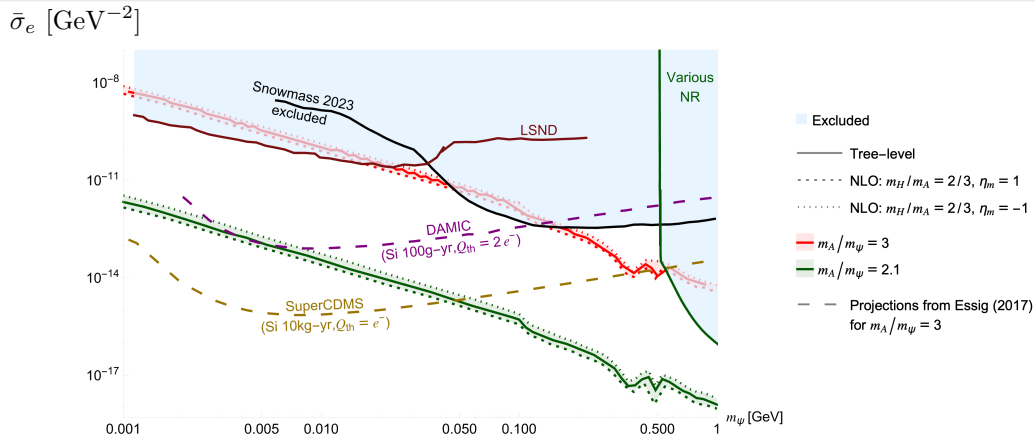

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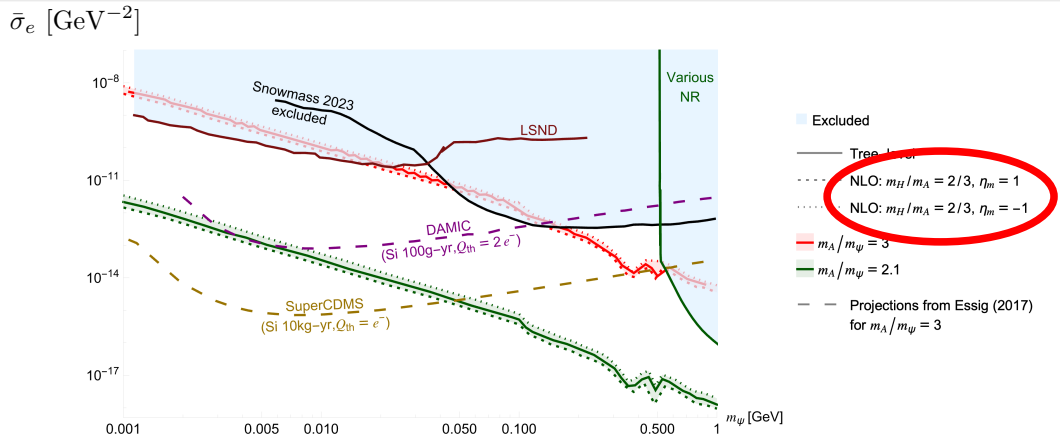
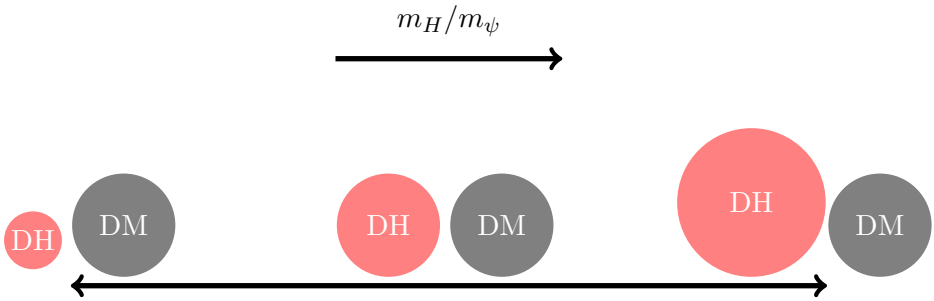


Usual scenario: no DH effects at tree level

LH, G. Mohlabeng, A. Mondol, & T.M.P. Tait (2026), *in prep.*. Excluded region & projections from Essig et. al (2022), *Snowmass2021 Cosmic Frontier: The landscape of low-threshold dark matter direct detection in the next decade* and Essig et. al (2016), *Direct Detection of sub-GeV Dark Matter with Semiconductor Targets.*

Tree-level dark Higgs scenarios



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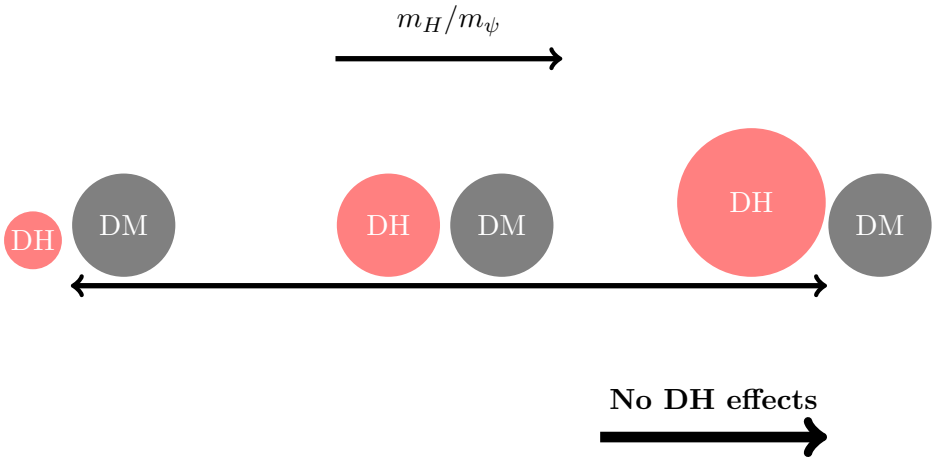

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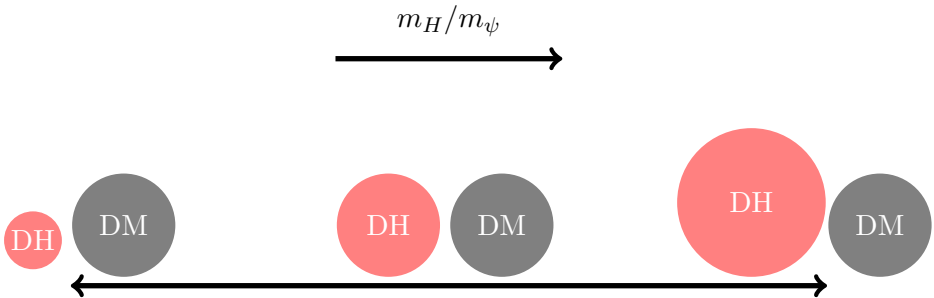
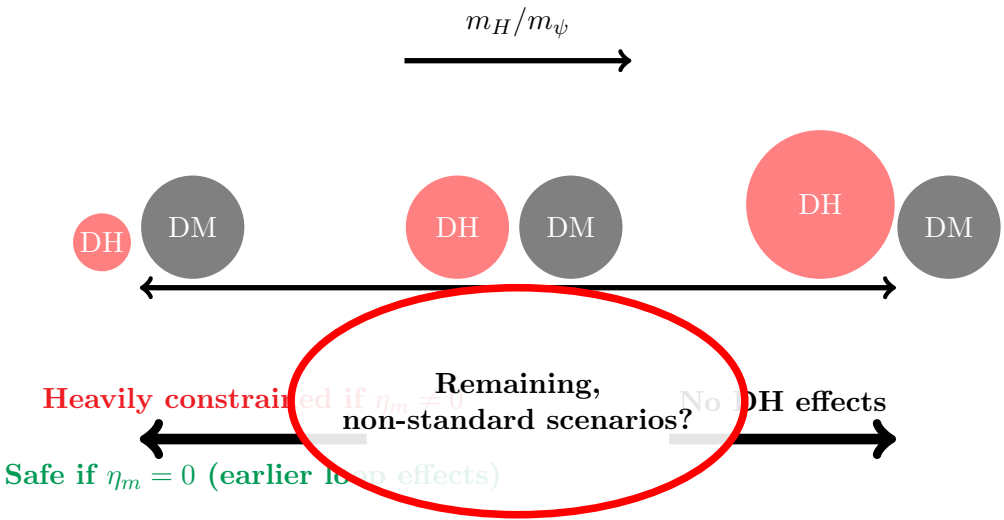


Heavily constrained if $\eta_m \neq 0$

Safe if $\eta_m = 0$ (earlier loop effects)

No DH effects

Tree-level dark Higgs scenarios



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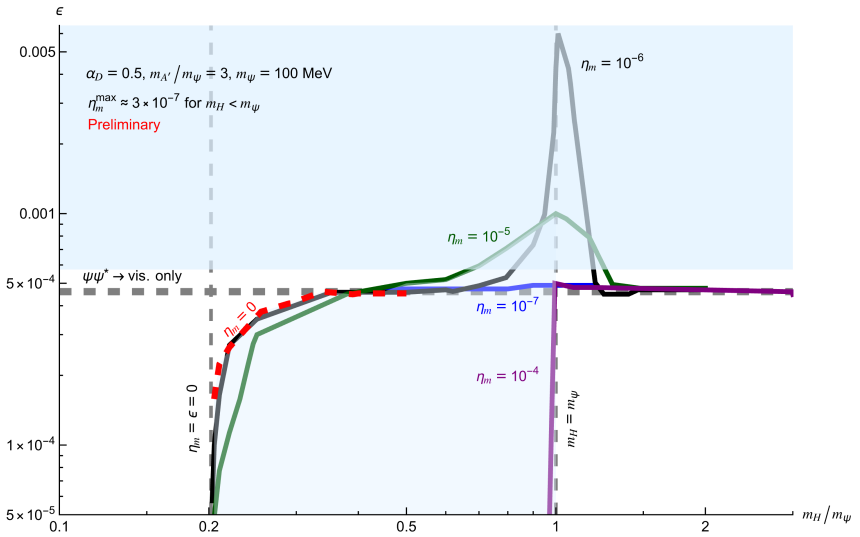

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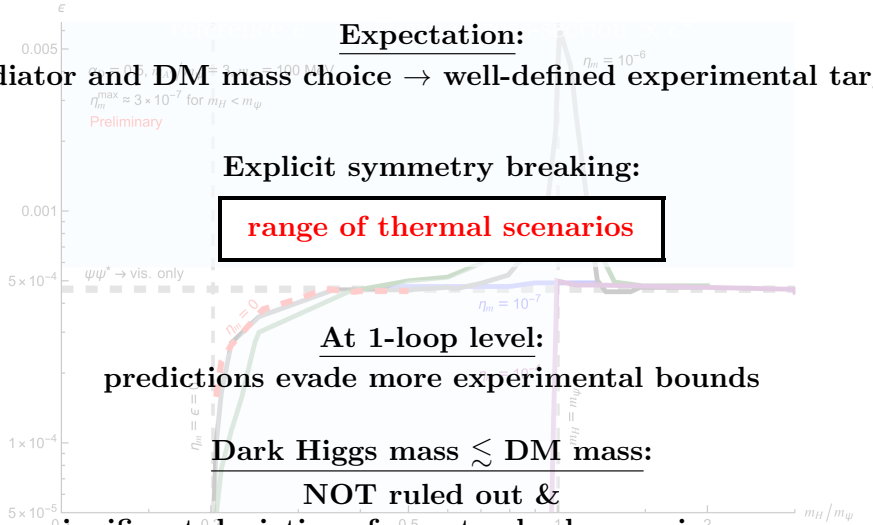
Summary



Expectation:

mediator and DM mass choice → well-defined experimental target

Explicit symmetry breaking:

range of thermal scenarios

At 1-loop level:

predictions evade more experimental bounds

Dark Higgs mass $\lesssim$ DM mass:

NOT ruled out &

significant deviations from standard scenario appear