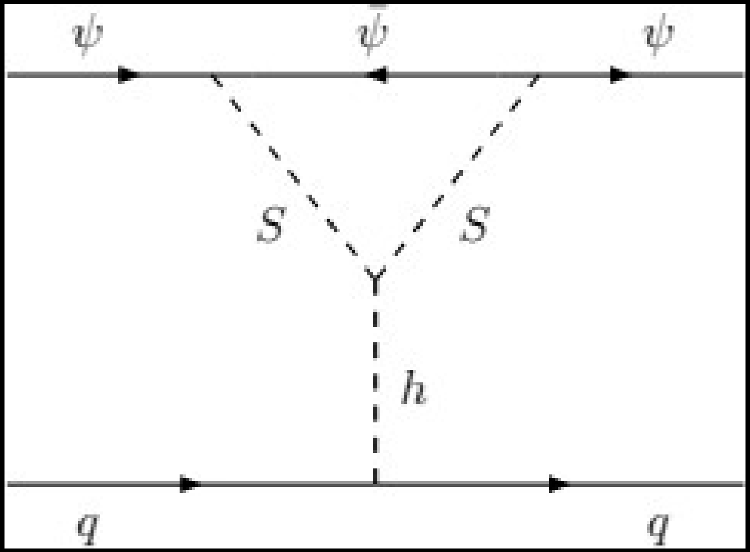
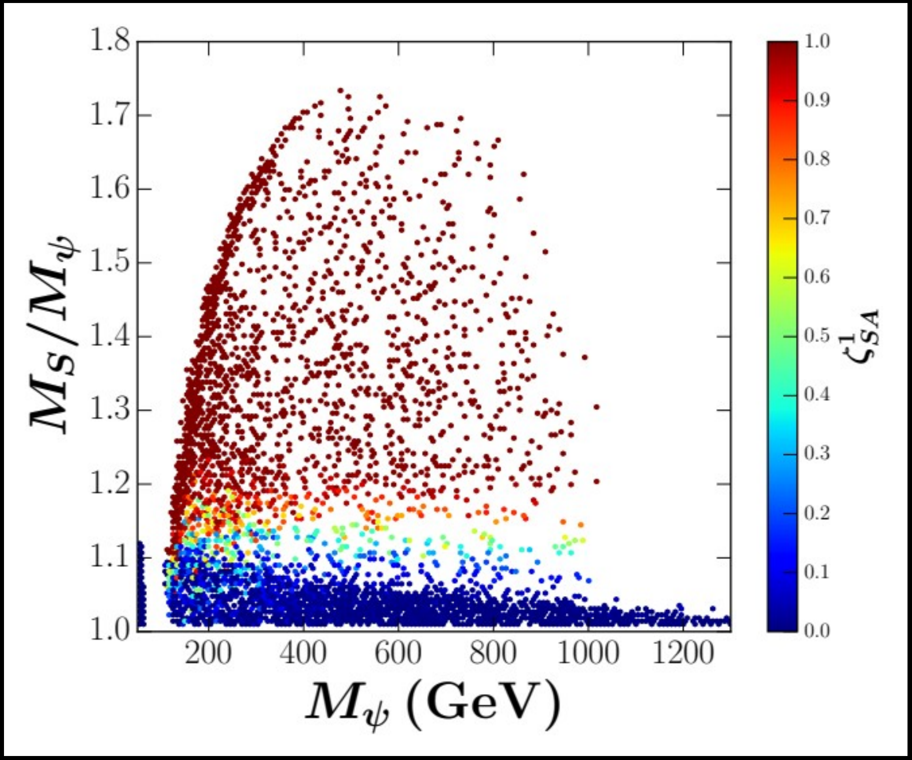
Two-component fermion and scalar dark matter from a Z_4 symmetry





Based on Phys.Rev.D 105 (2022) 9, 095026, with Oscar Zapata

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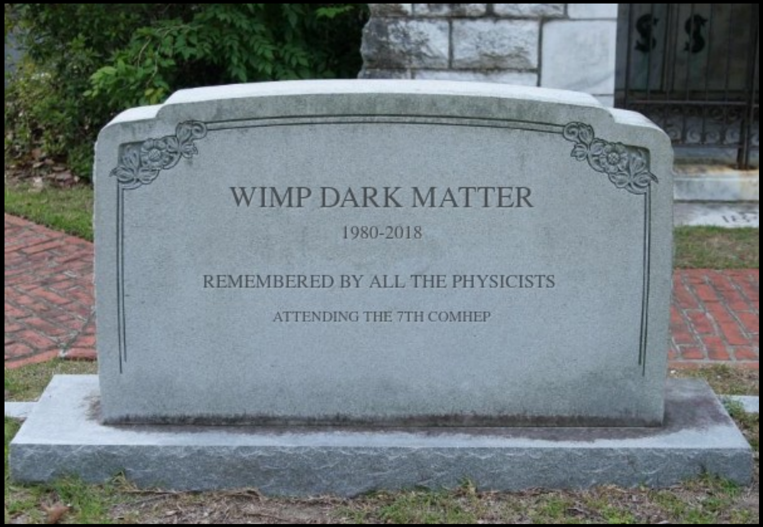
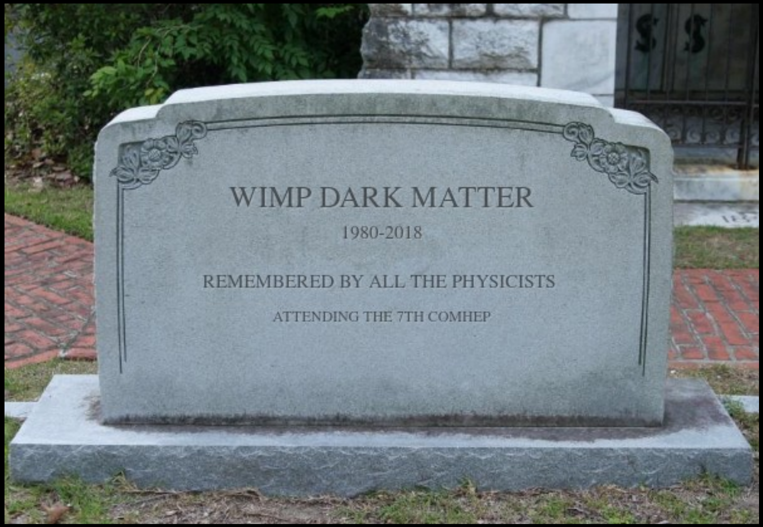
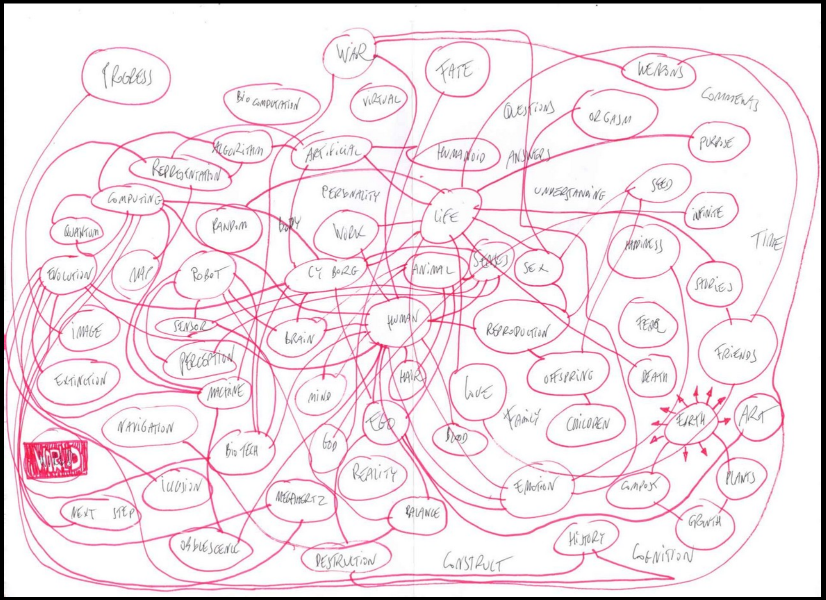


1. WIMPs are dead

In this talk I will debunk two myths related to dark matter



1. WIMPs are dead



2. DM models must be complicated

We consider a scenario with 1 scalar (S) and 1 fermion (ψ) charged under a Z_4

$S \rightarrow -S$ and $\psi \rightarrow i\psi$ under the Z_4

Cai and Spray
1509.08481

$$\mathcal{L} = \frac{1}{2}\mu_S^2 S^2 + \lambda_S S^4 + \frac{1}{2}\lambda_{SH}|H|^2 S^2 + M_\psi \overline{\psi}\psi + \frac{1}{2}\left[y_s \overline{\psi^c}\psi + y_p \overline{\psi^c}\gamma_5\psi + \text{h.c.}\right] S,$$

S is stable provided $M_S < 2M_\psi$

ψ is always stable

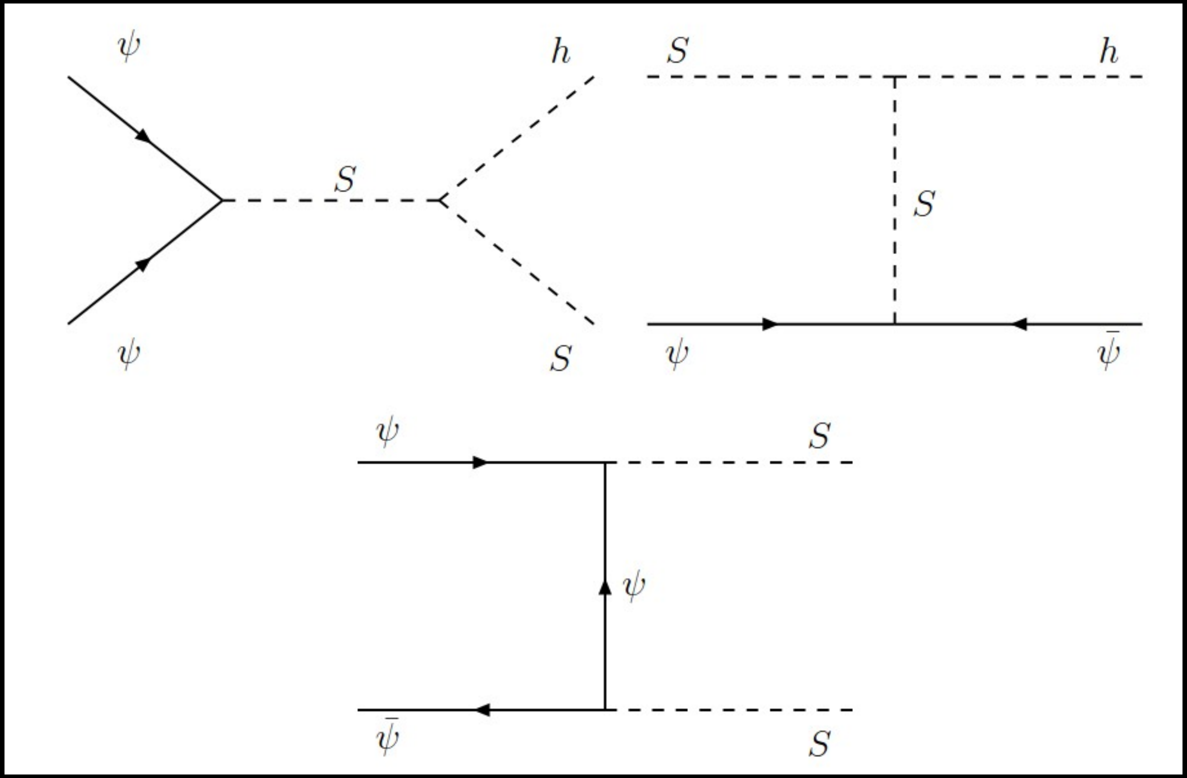
The model is remarkably simple and gives rise to new phenomena

It contains just five free parameters

M_S, M_ψ
λ_{SH}, y_s, y_p

It predicts semi-annihilations:

And DM conversions:



Different processes contribute to the relic densities in this model

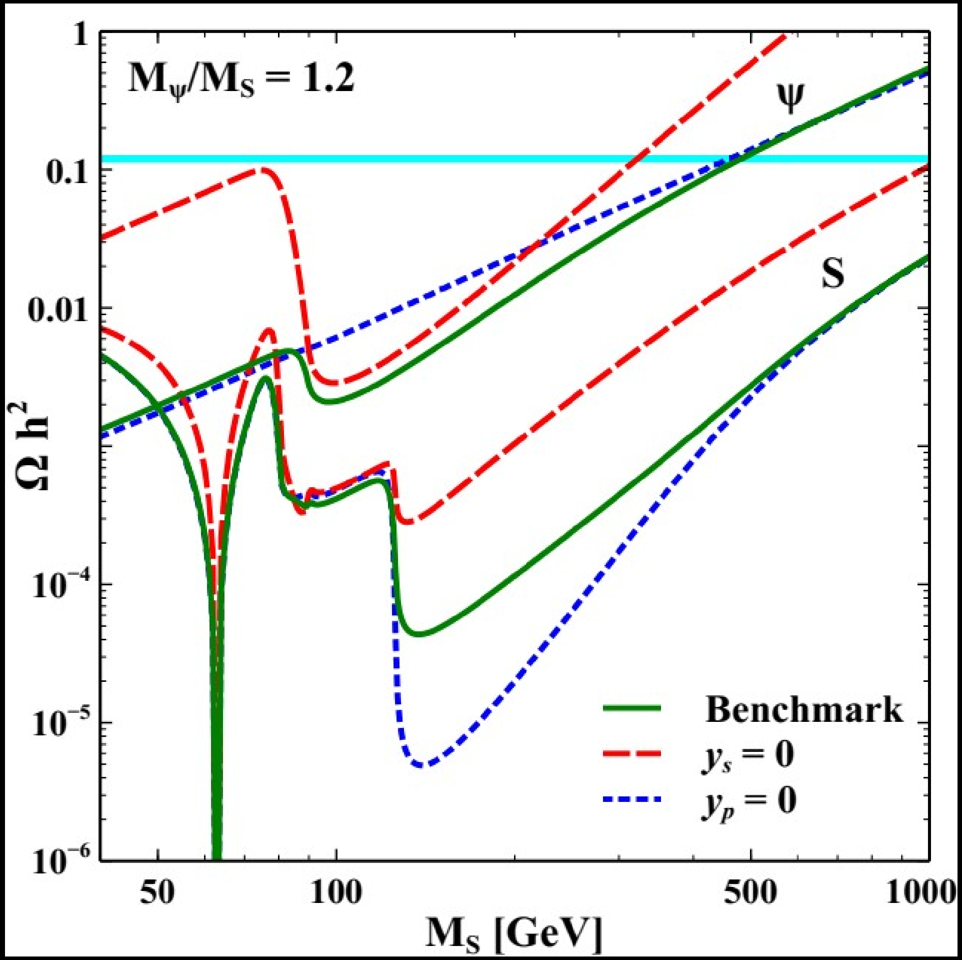
ψ Processes	Type
$\psi + \bar{\psi} \to S + S$	1122
$\psi + \psi \to S + h$	1120

S Processes	Type
$S + S \to SM + SM$	2200
$S + S \to \psi + \bar{\psi}$	2211
$S + h \to \psi + \psi$	2011
$S + \psi \to \bar{\psi} + h$	2110

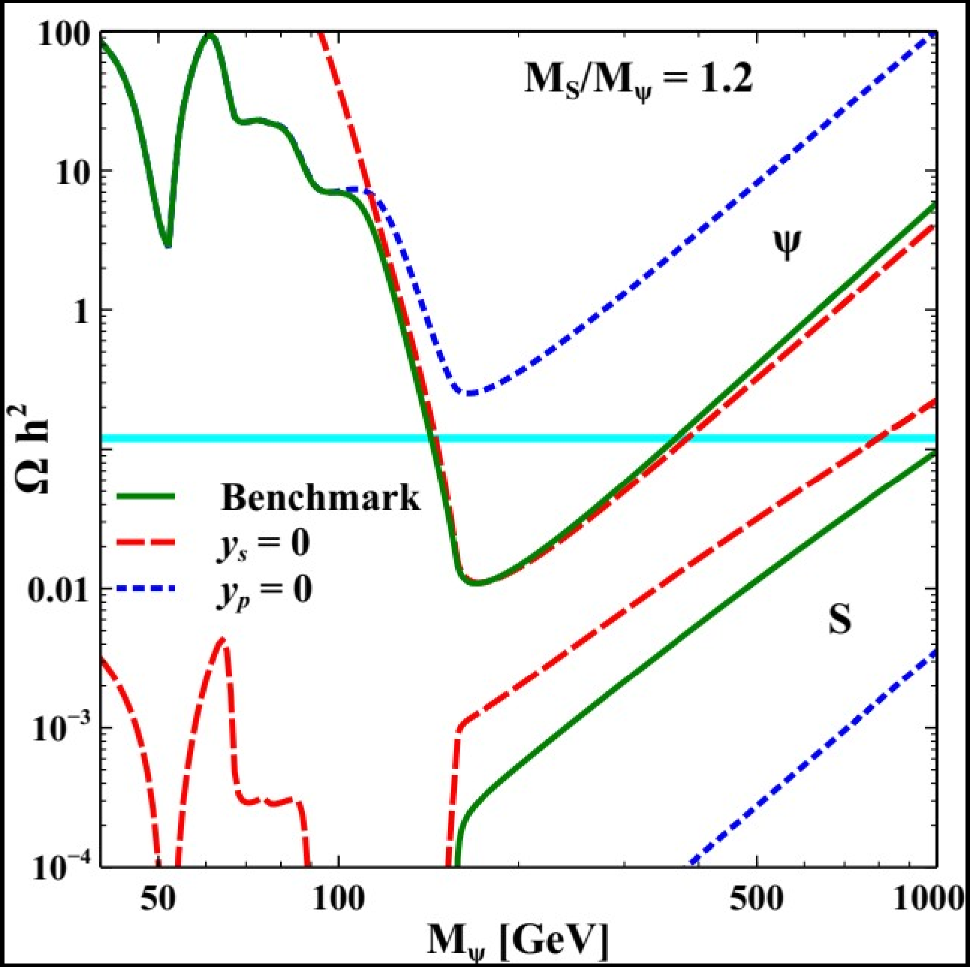
$$\frac{dn_\psi}{dt} = -\sigma_v^{1120}\left(n_\psi^2 - n_S\frac{\bar{n}_\psi^2}{\bar{n}_S}\right) - \sigma_v^{1122}\left(n_\psi^2 - n_S^2\frac{\bar{n}_\psi^2}{\bar{n}_S^2}\right) - 3Hn_\psi,$$

$$\frac{dn_S}{dt} = -\sigma_v^{2200}\left(n_S^2 - \bar{n}_S^2\right) - \sigma_v^{2211}\left(n_S^2 - n_\psi^2\frac{\bar{n}_S^2}{\bar{n}_\psi^2}\right) - \frac{1}{2}\sigma_v^{1210}\left(n_\psi n_S - n_\psi \bar{n}_S\right)$$
$$+ \frac{1}{2}\sigma_v^{1120}(n_\psi^2 - n_S\frac{\bar{n}_\psi^2}{\bar{n}_S}) - 3Hn_S.$$

We used micrOMEGAs to solve these equations and compute Ω_S and Ω_ψ



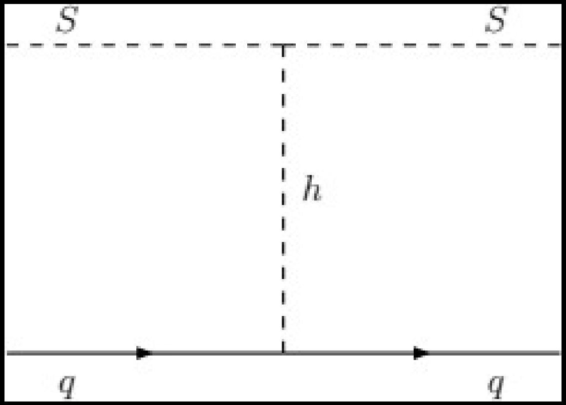
$M_S < M_\psi$



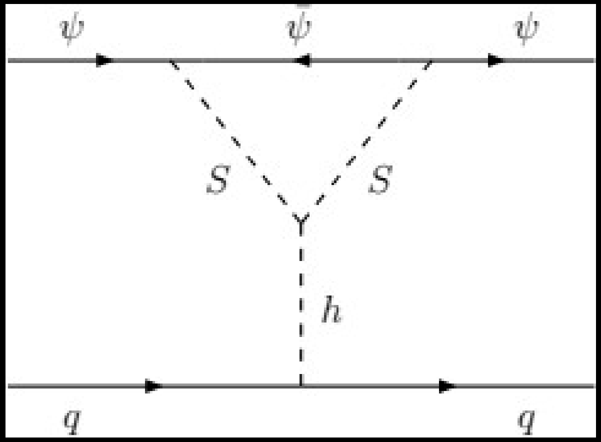
$M_\psi < M_S$

Dark matter direct detection is induced by higgs-mediated diagrams

At tree-level for the scalar

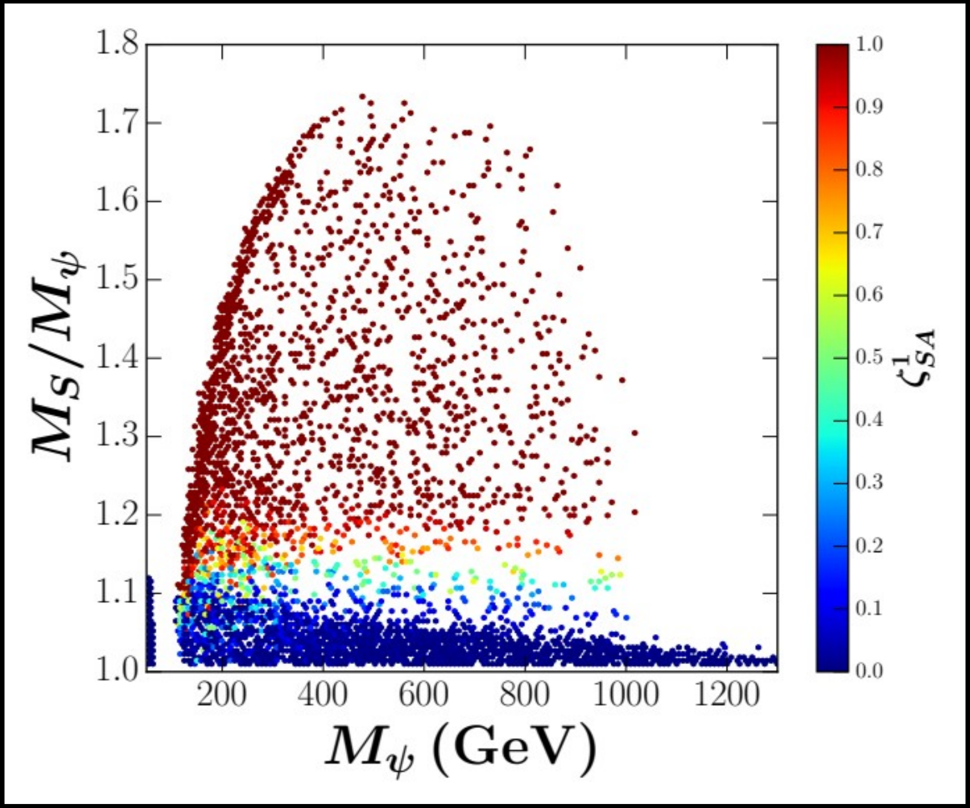


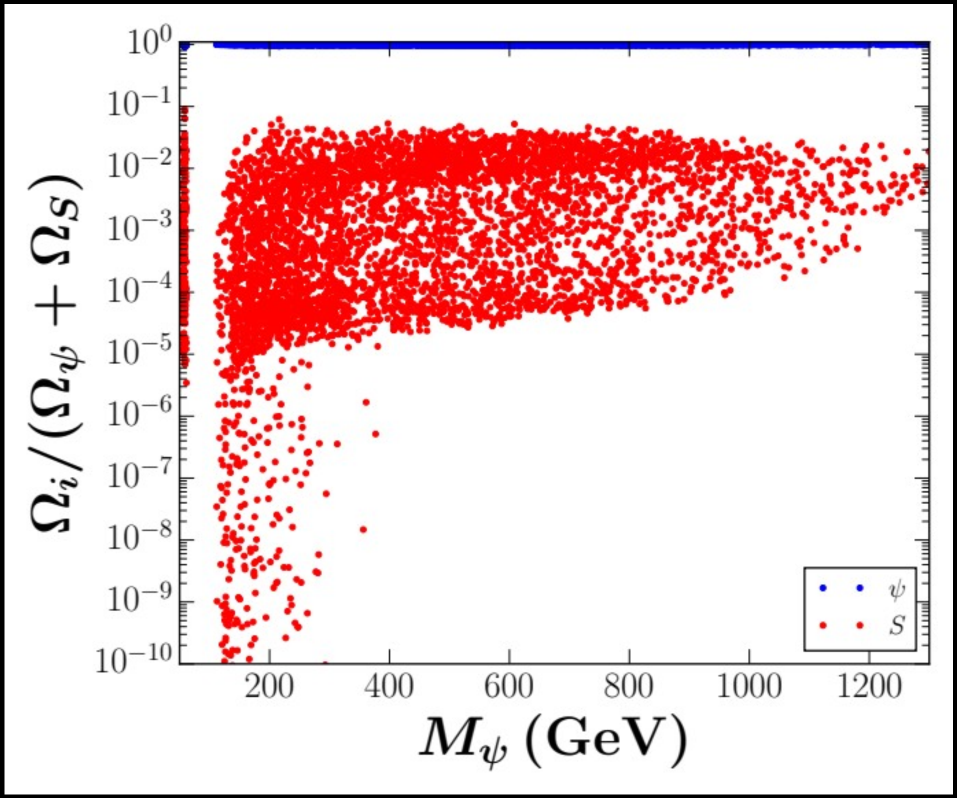
At 1-loop for the fermion



Current DD limits are relevant for both

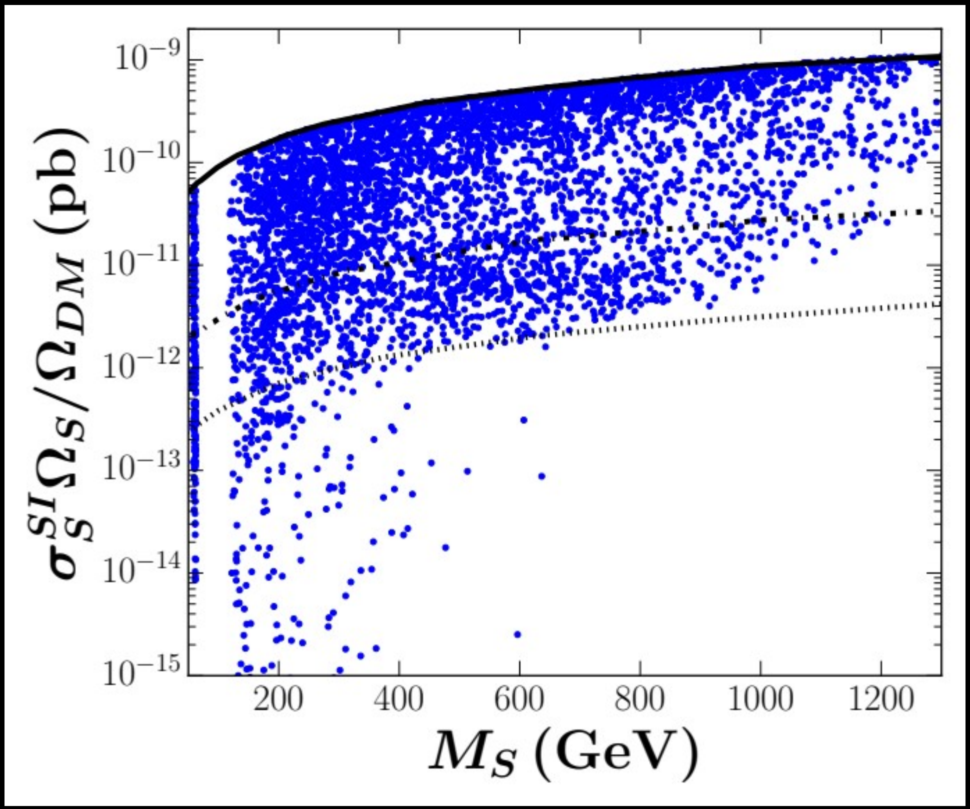
For M_ψ < M_S, semiannihilations are crucial and ψ dominates the DM density

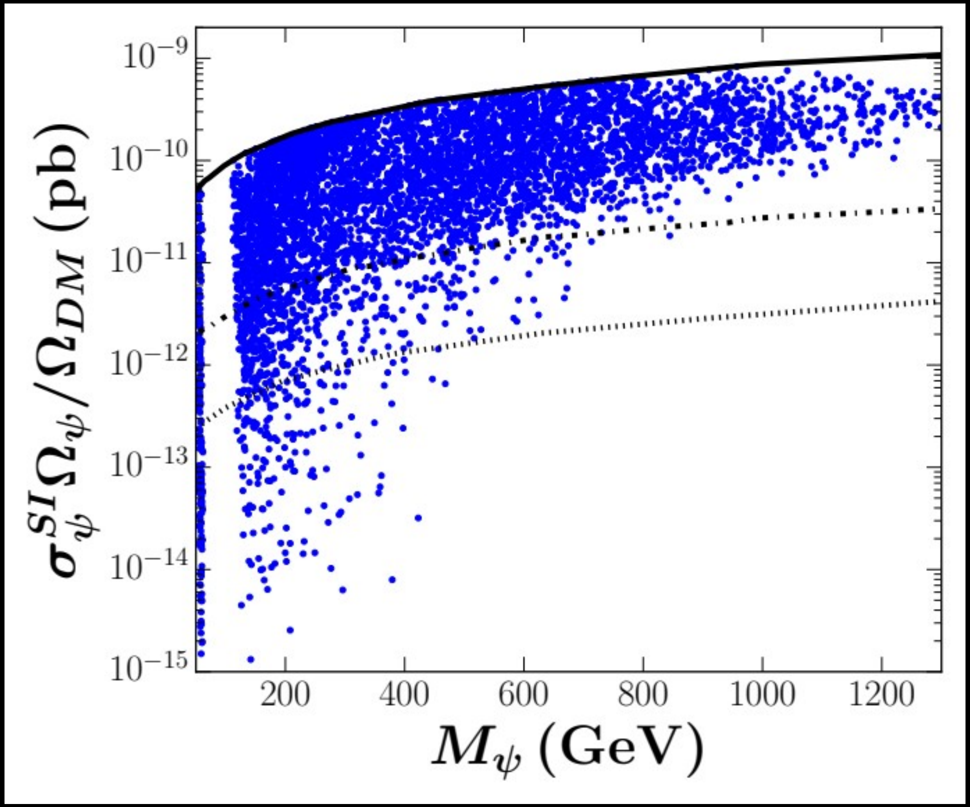




The whole range of DM masses becomes viable

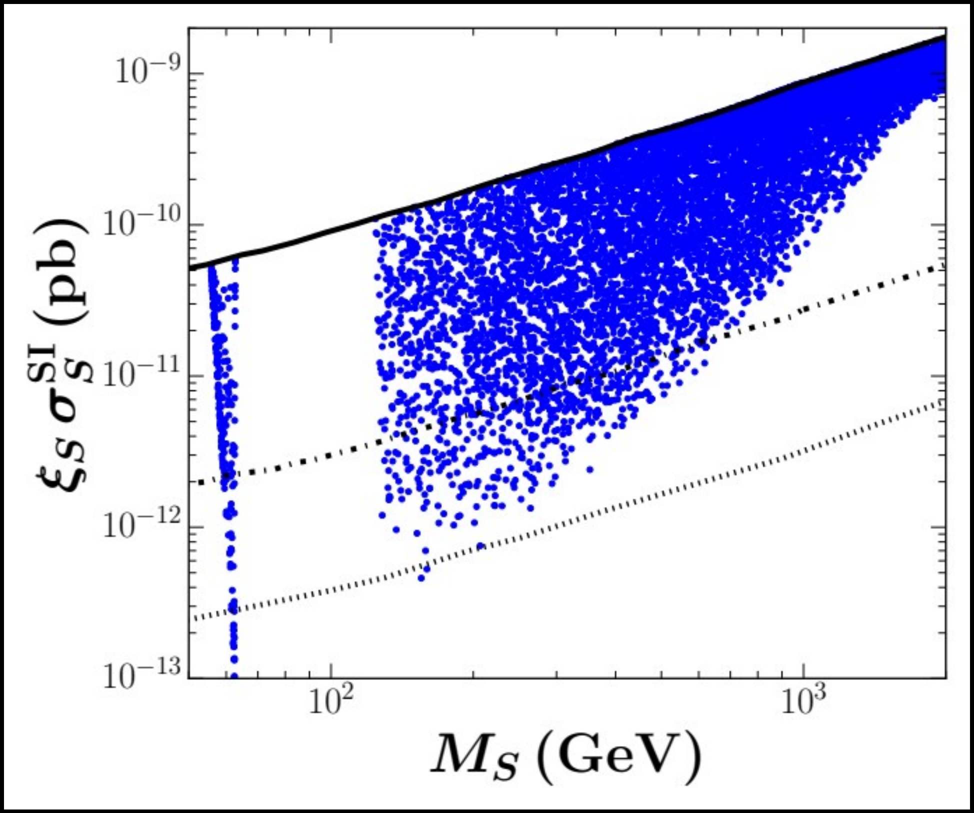
For $M_\psi < M_S$, both DM particles may be detected in direct detection experiments

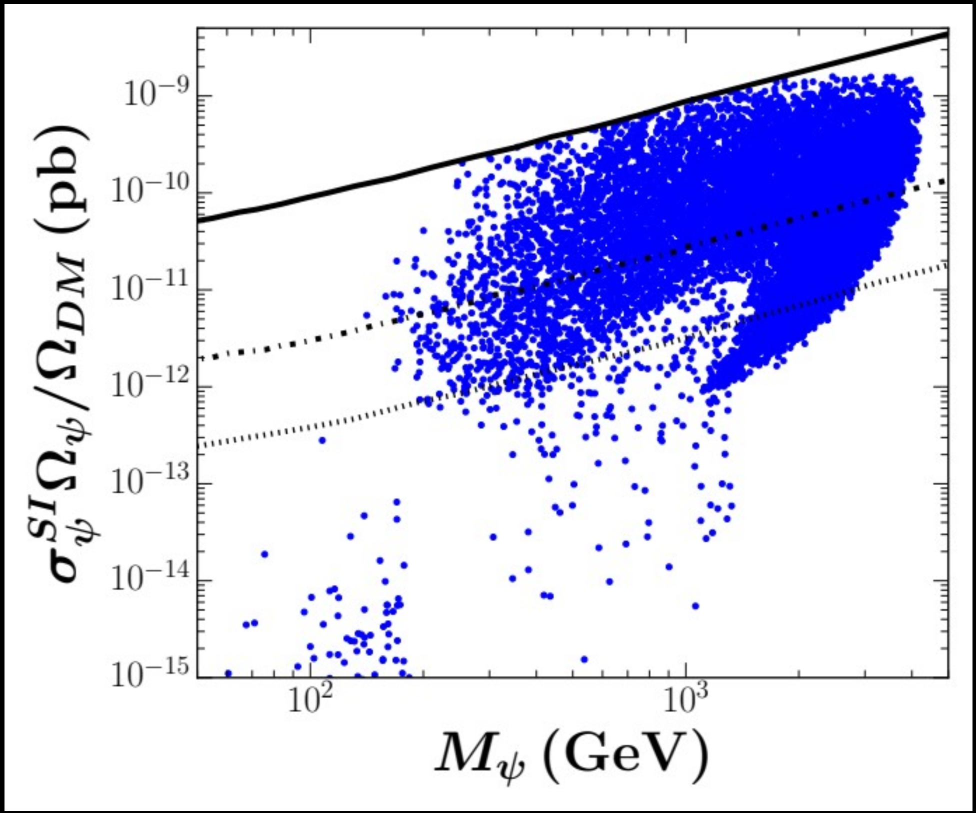




This model can be distinguished from the conventional scenarios

For $M_S < M_\psi$, the direct detection prospects are even better





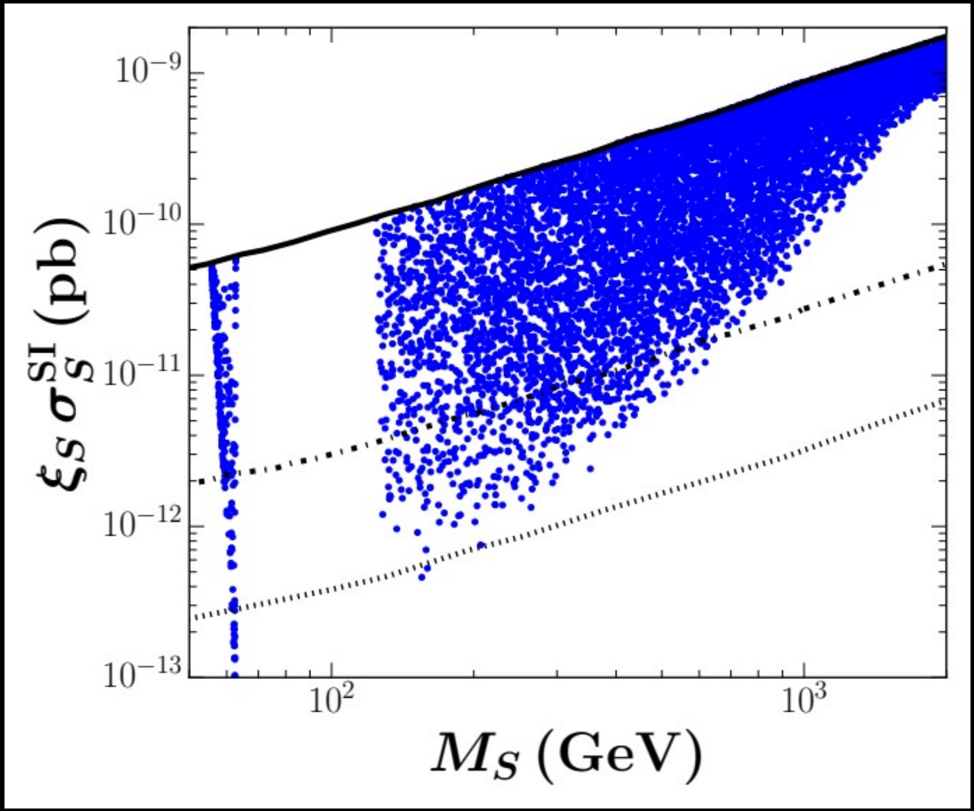
The detection of S is practically guaranteed in this case

We analyzed a simple and viable model for WIMP dark matter

It contains just five parameters

It predicts new DM processes

It can be tested via Direct Detection



This Z_4 model can be easily generalized to other scenarios

A different Z_N: Z_3, Z_5, Z_6, etc.

The Z_3 includes more free parameters

More DM particles: scalars or fermions

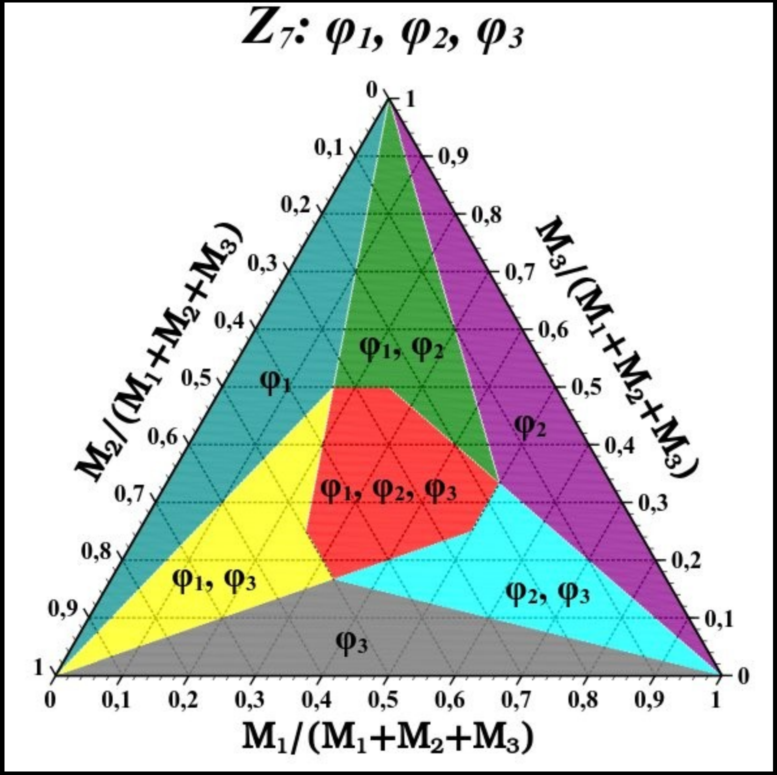
S: Z_4 or higher
ψ: Z_5 or higher

Z_N symmetries with N≥3 may lead to multi-component dark matter

A Z_N can stabilize multiple particles

Battel, 1007.0045

DM stability depends on the masses



New dark matter processes

Yaguna and Zapata, 1911.05515

These Z_N scenarios are examples of Higgs-portal models

Z_N singlets

Z_N charged
At least 1 scalar