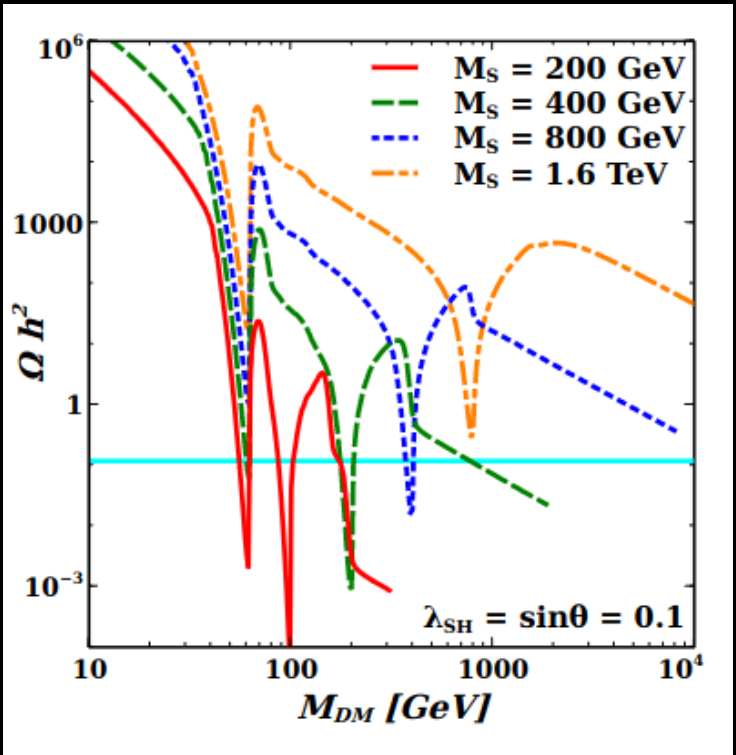
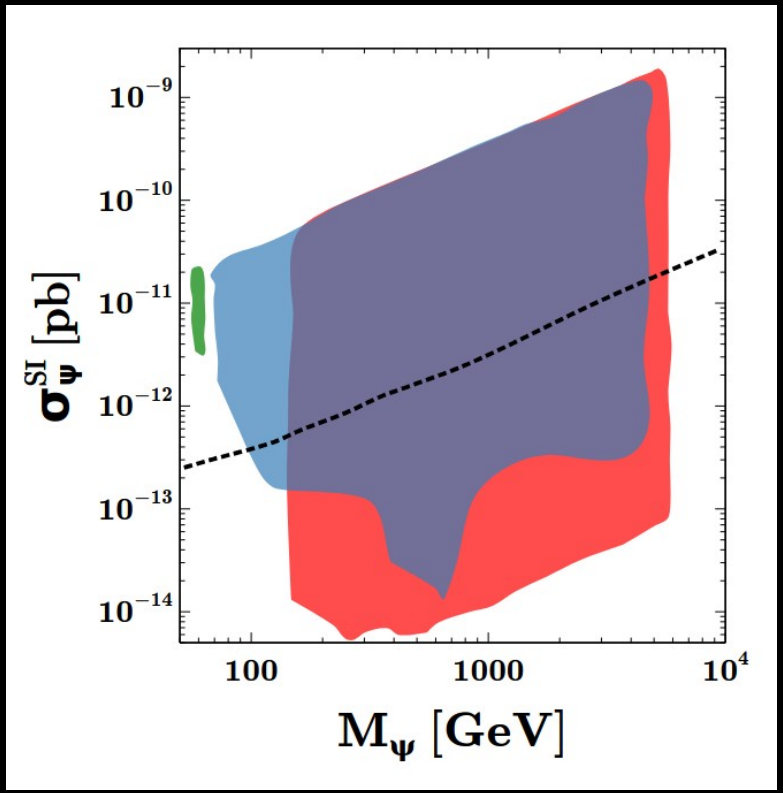
A new scenario for singlet Dirac dark matter





JCAP 06 (2024) 049, with Oscar Zapata

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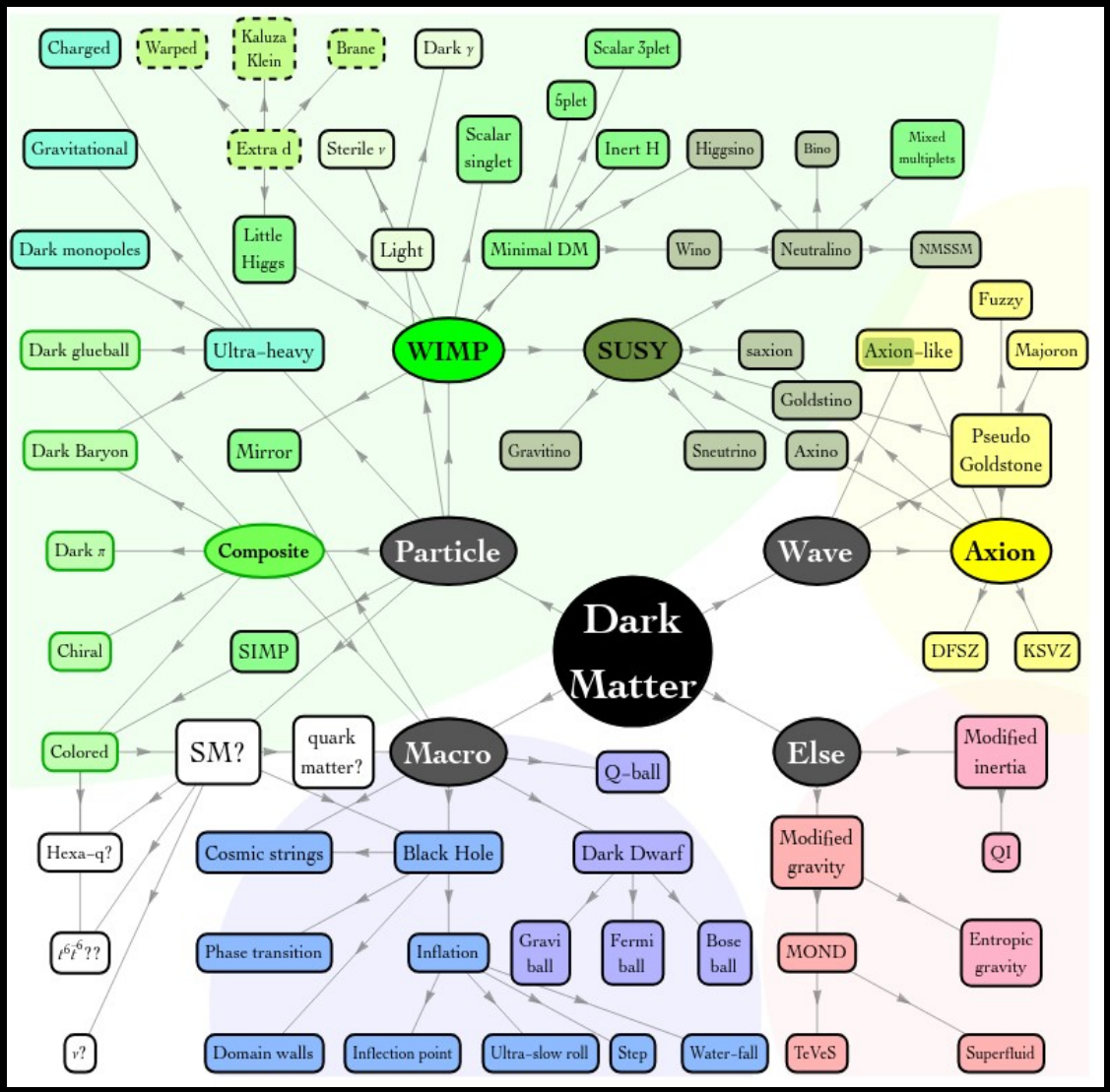
2024

Why another dark matter model?

Hundreds have been proposed

But some simple ones remain to be explored



Cirelli et al, 2024

Minimal models are an appealing alternative to solve the DM puzzle

Extend the SM but just a little bit

Few new fields

A small number of free parameters

Predictive!

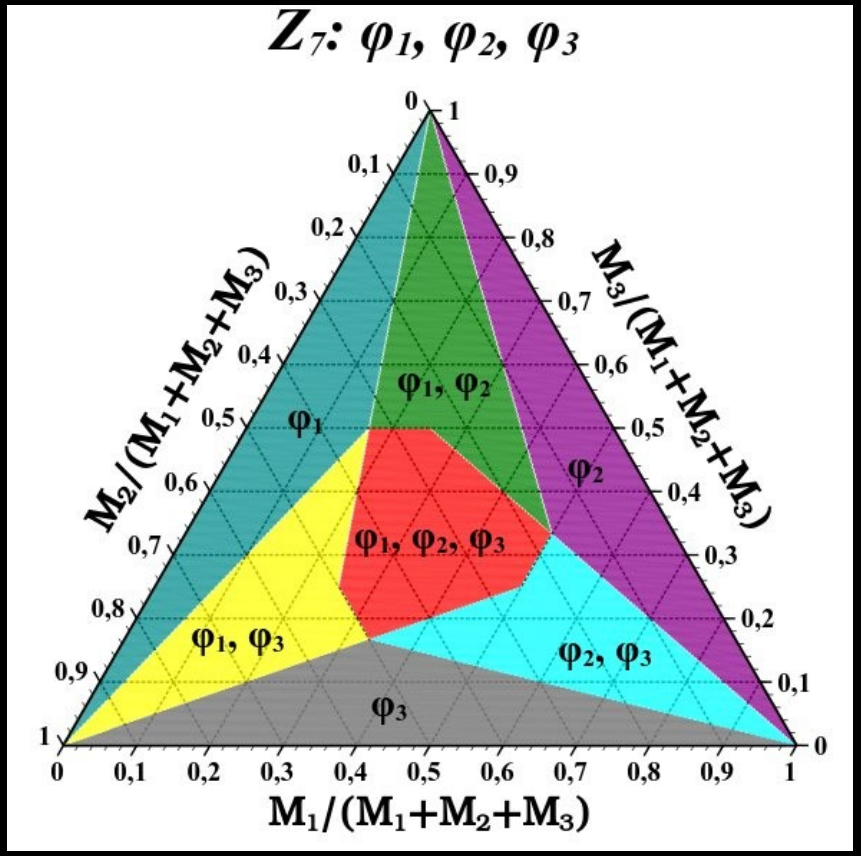
A DM stabilizing symmetry

Z_2?

Z_N symmetries with N>2 give rise to a much richer phenomenology

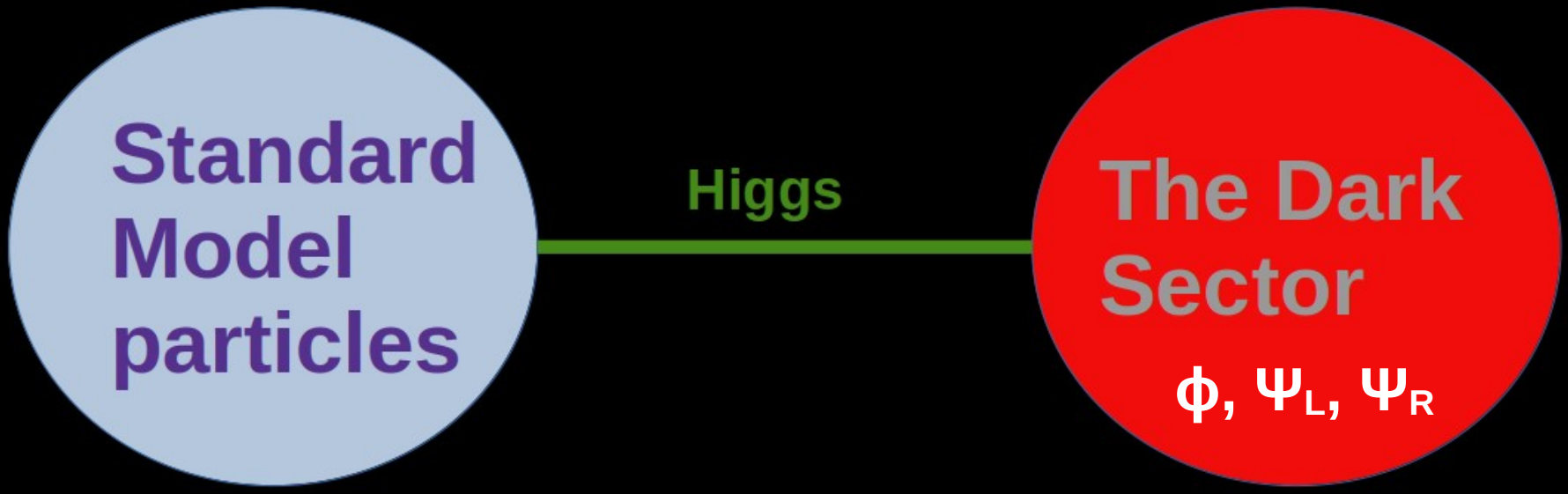
Multi-component DM

Novel DM processes



Could they be useful also for single-component DM?

We consider a scenario with 1 scalar and 2 chiral fermions charged under a Z_6



Z_6 singlets

SM singlets but Z_6-charged

$$\phi \to \omega_6^3\,\phi, \quad \psi_L \to \omega_6\,\psi_L, \quad \psi_R \to \omega_6^4\,\psi_R; \qquad \omega_6 = e^{\frac{2\pi i}{6}}\,.$$

In this model the dark matter particle is a Dirac fermion

The new fields interact with one another

$$\mathcal{L}_\psi = \; -y_s \overline{\psi}_L \psi_R \, \phi + \text{h.c.}$$

ϕ acquires a non-zero vev

$$\phi = (\phi_R + v_\phi)$$

Ψ_L and Ψ_R form a Dirac fermion

The dark matter

The new scalar mixes with the SM Higgs boson

The new scalar potential is

$$-\frac{1}{2}\mu_\phi^2\phi^2+\frac{1}{4}\lambda_\phi\phi^4+\frac{1}{2}\lambda_{SH}|H|^2\phi^2$$

A new mixing angle in the scalar sector

(ϕ, h) → (S, H)

sin θ

New collider signals

H is not exactly SM

This model is extremely simple

Two new particles

The DM and a new scalar

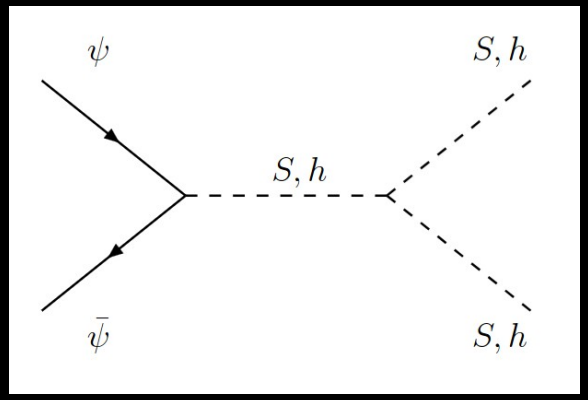
Just 4 free parameters!

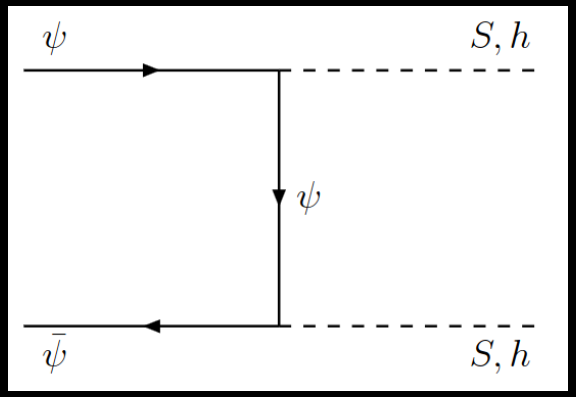
$$m_\psi, M_S, \sin\theta, \lambda_{SH}$$

Is it viable?

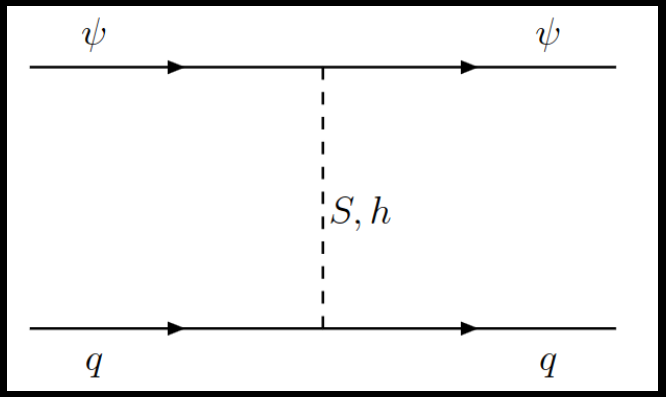
In this model the dark matter fermion couples directly only to the scalars

DM annihilations:





DM direct detection:

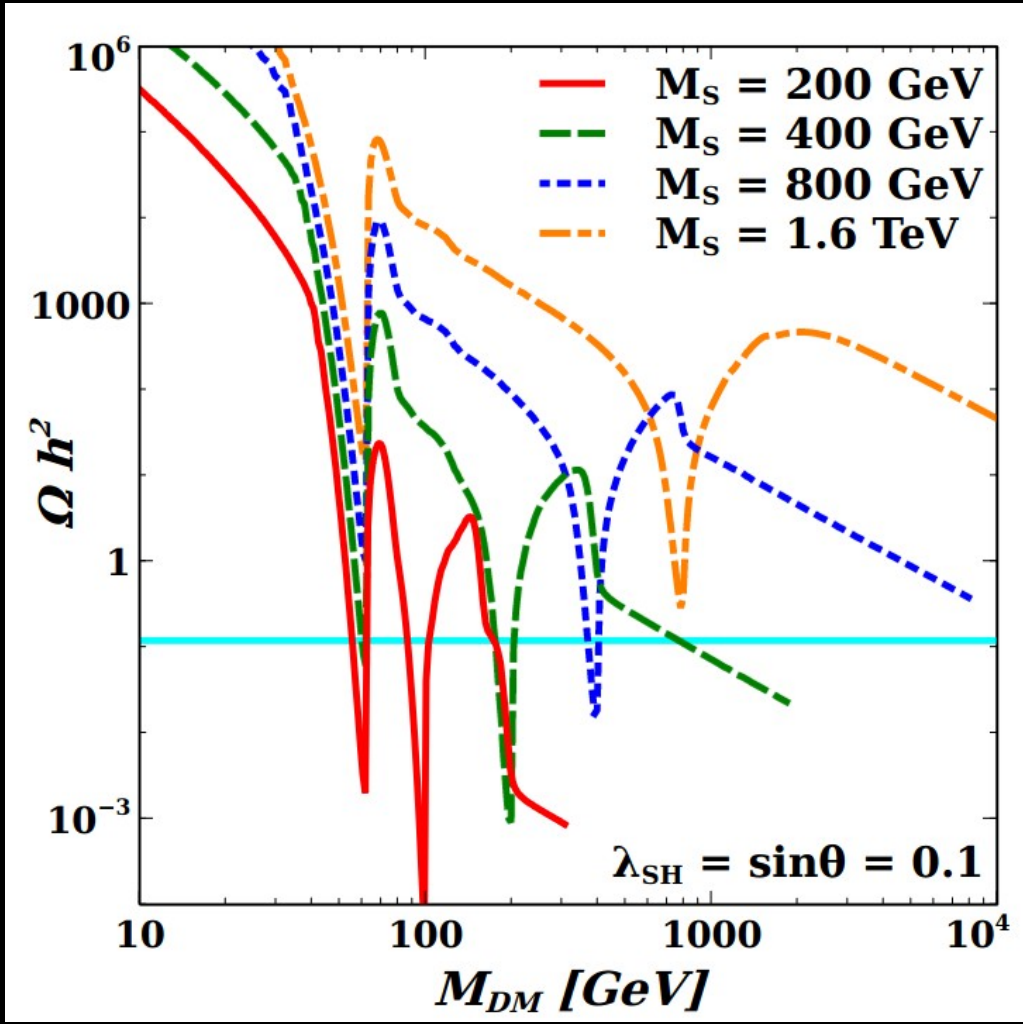


The dark matter constraint can be satisfied in different regions

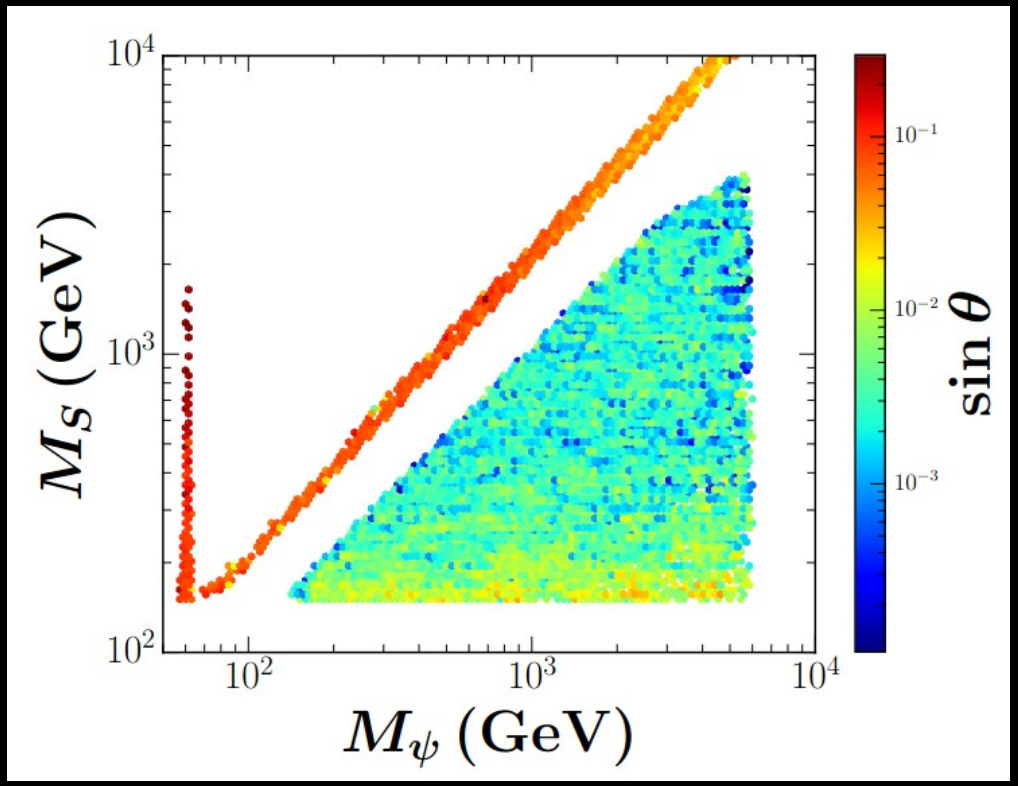
At the S and H resonances

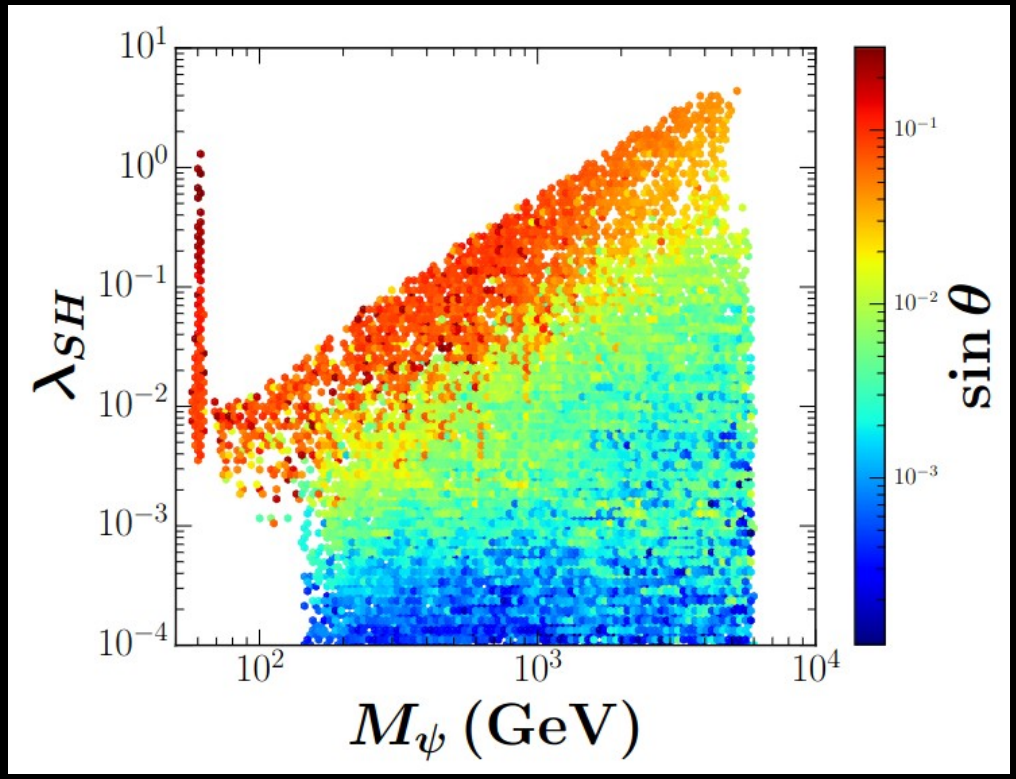
At higher masses: $\psi\psi \rightarrow SS$

Are they consistent with direct detection?

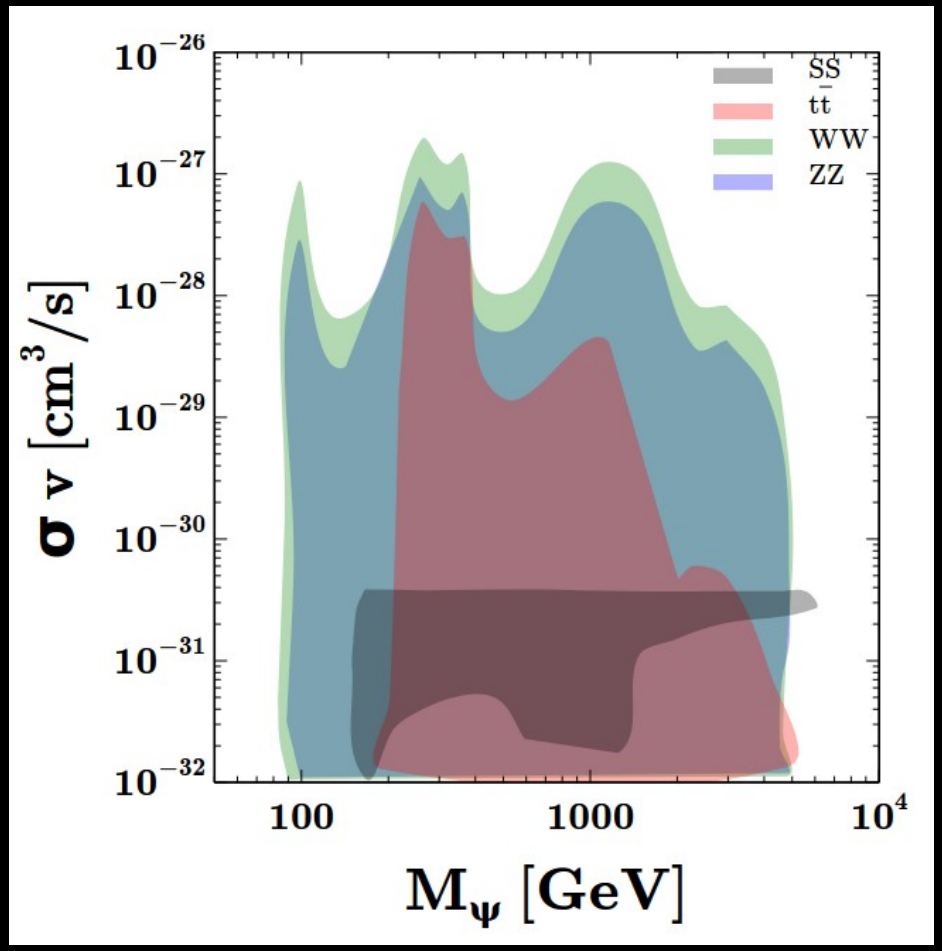


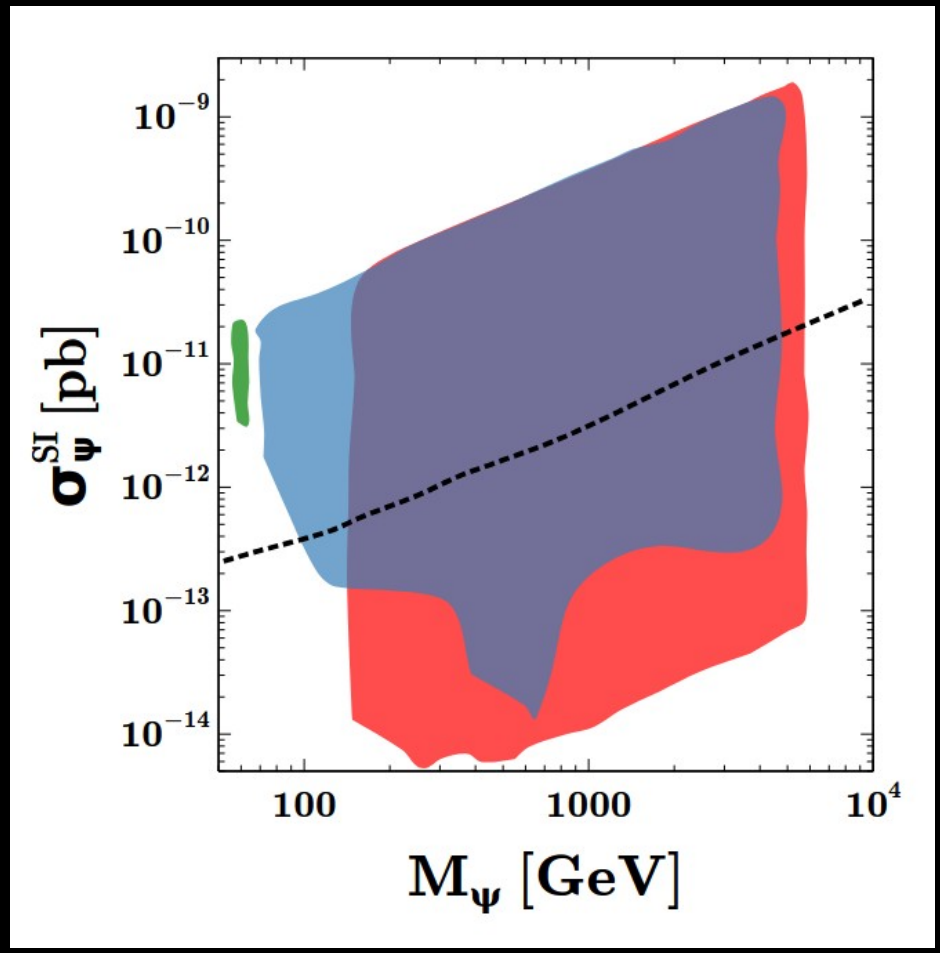
The viable regions span a wide range of dark matter masses





In this model, DM direct detection is quite promising



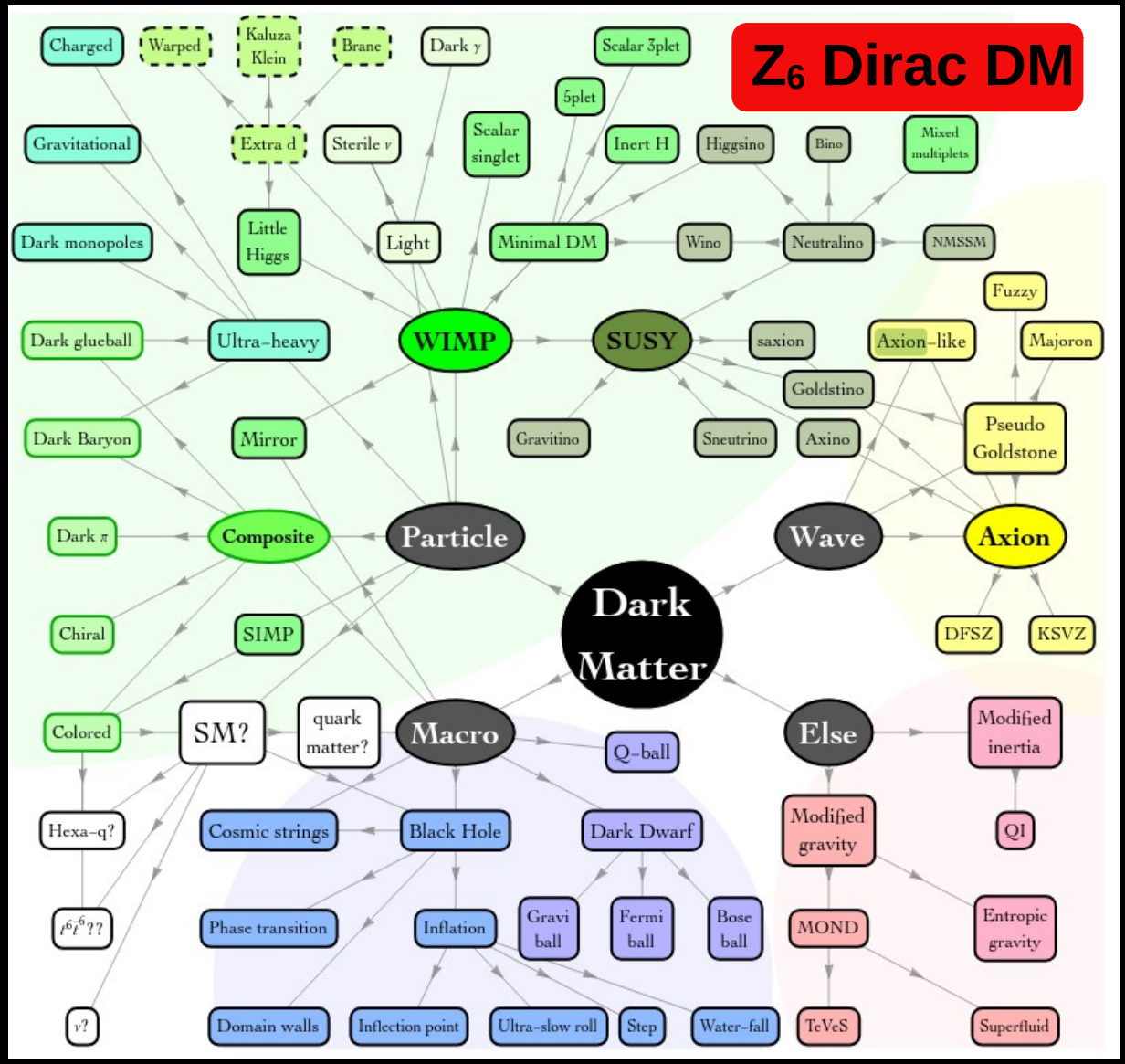


I presented the minimal model for singlet Dirac dark matter

It is based on a Z_6 symmetry

It contains just four parameters

It is viable and testable



A Z_2-based analogous model is not that simple

Fermion is odd while the scalar is even

$\psi \rightarrow -\psi$
$\phi \rightarrow \phi$

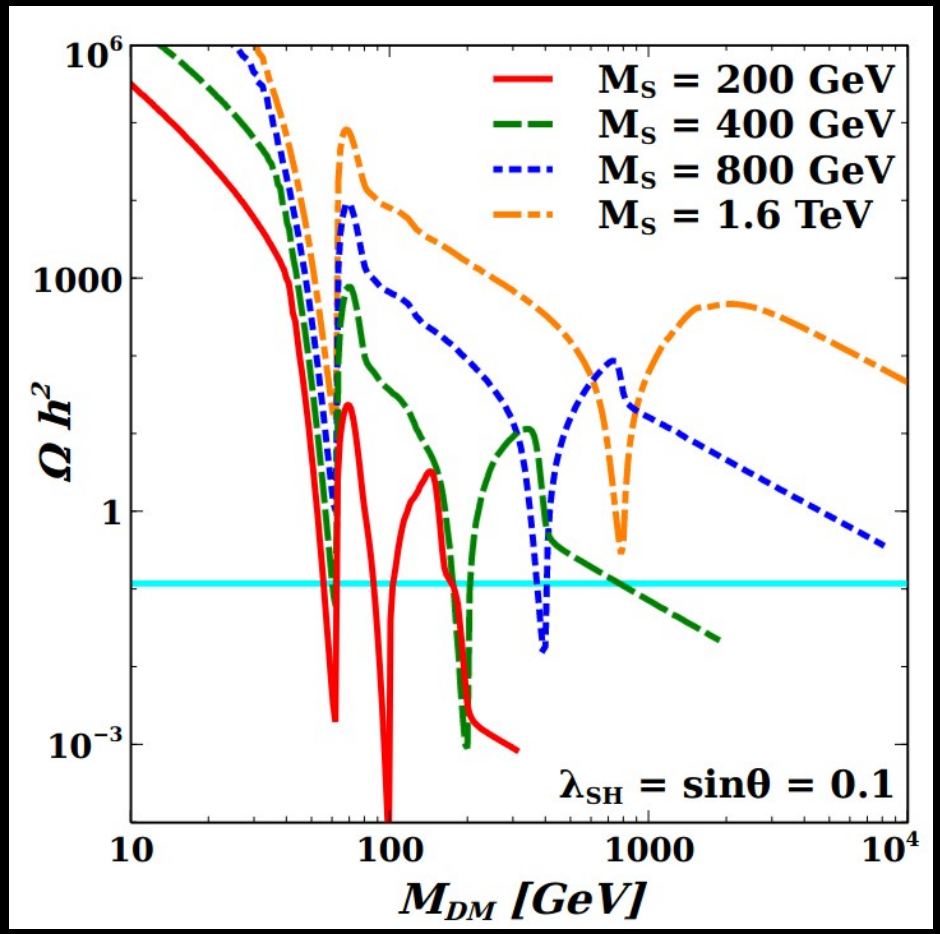
A bare mass term is allowed

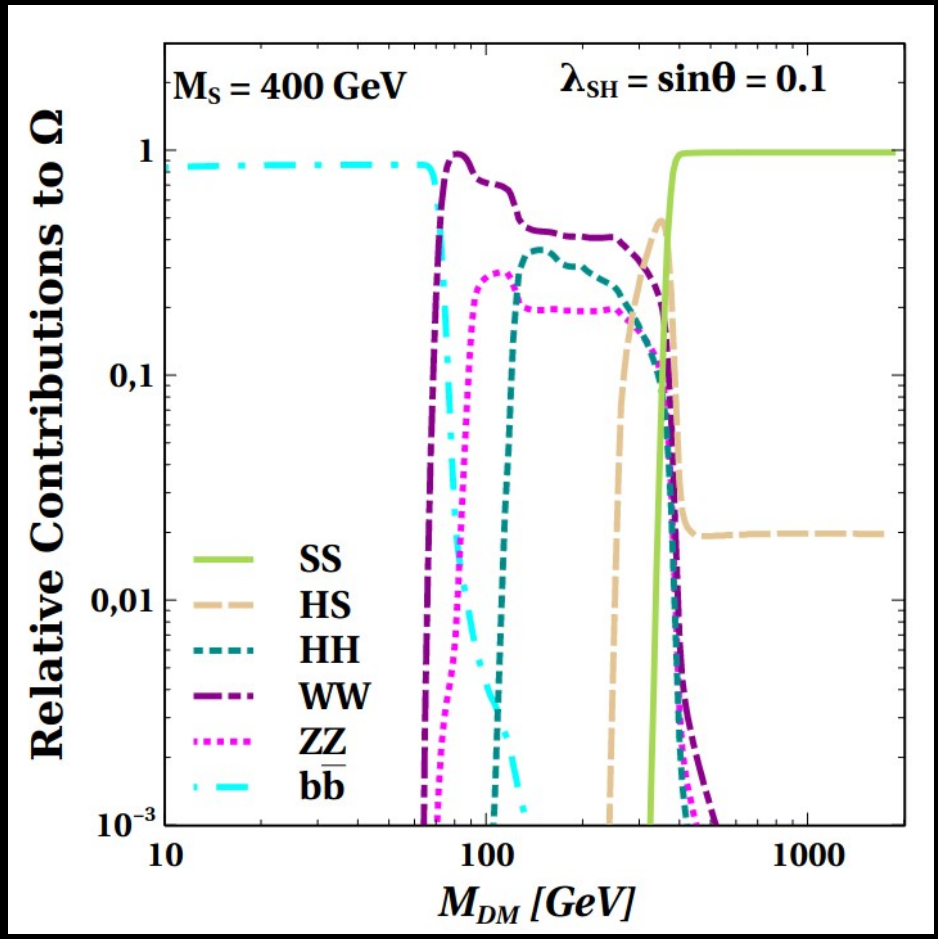
$M\bar{\psi}\psi$

Additional terms in the potential

$\phi^3, \phi H^2$

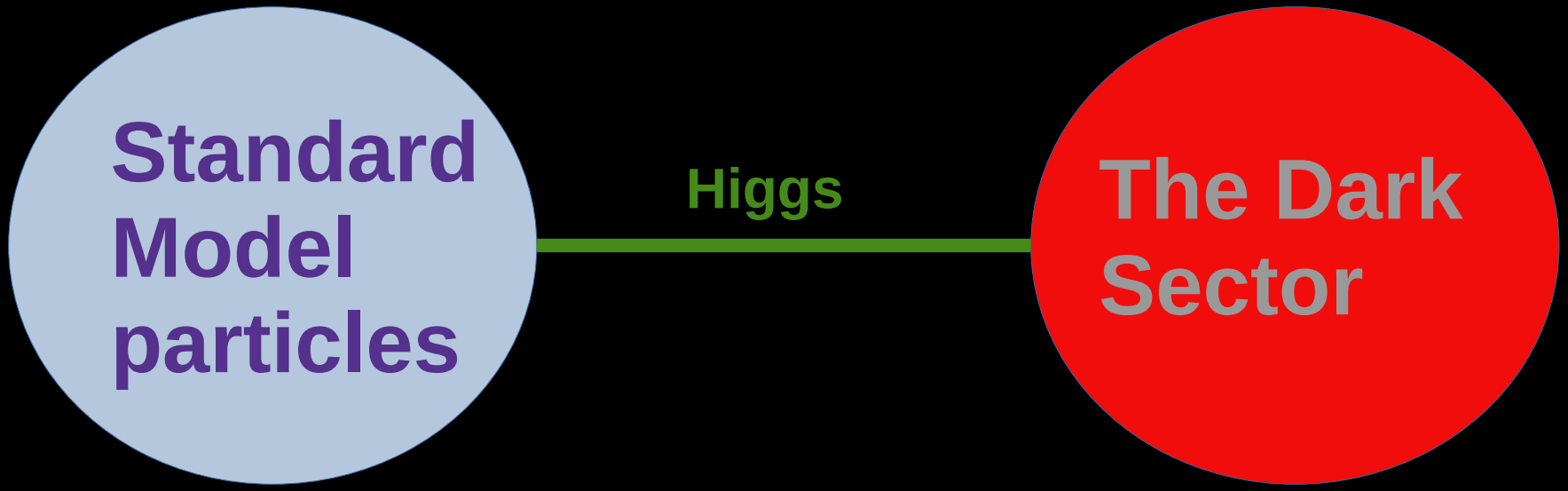
The dark matter constraint can be satisfied in different regions





Are they consistent with direct detection?

These Z_N scenarios are examples of Higgs-portal models



Z_N singlets

Z_N charged
At least 1 scalar