Radiative neutrino mass generation from WIMP dark matter

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Outline

Introduction

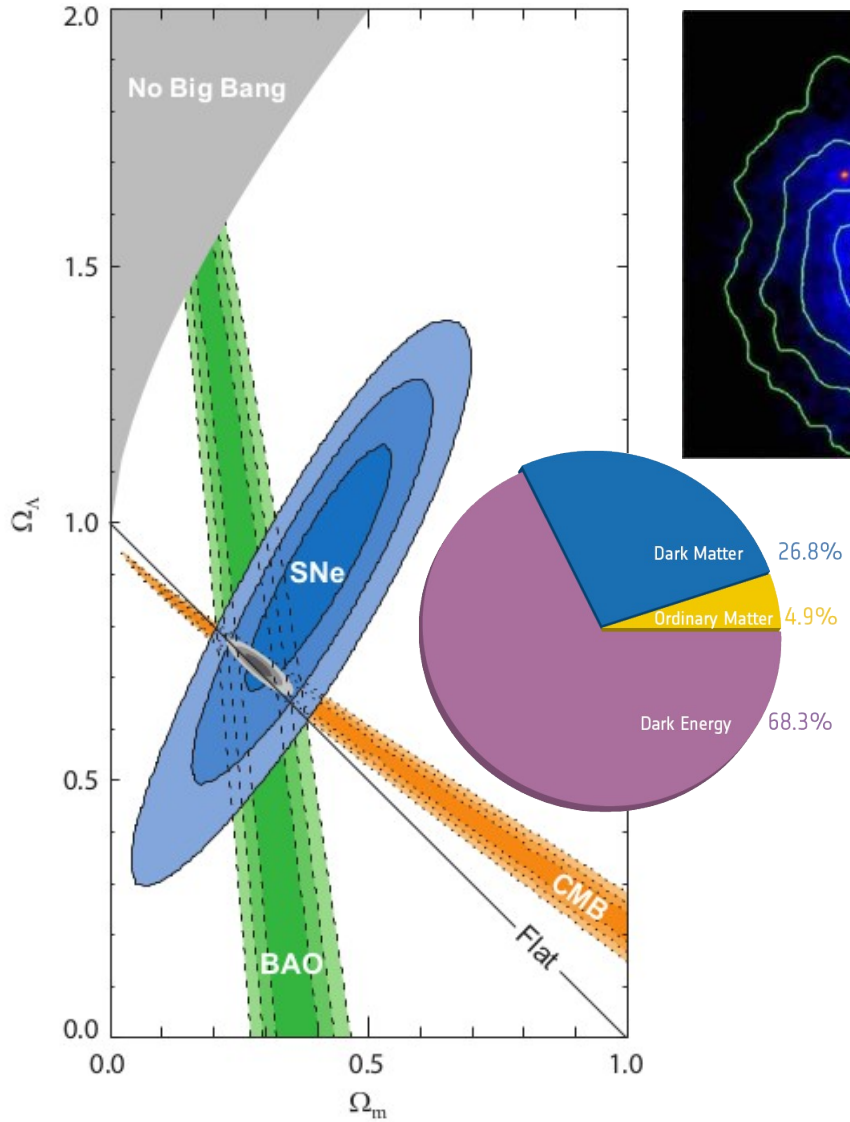
DM and neutrinos

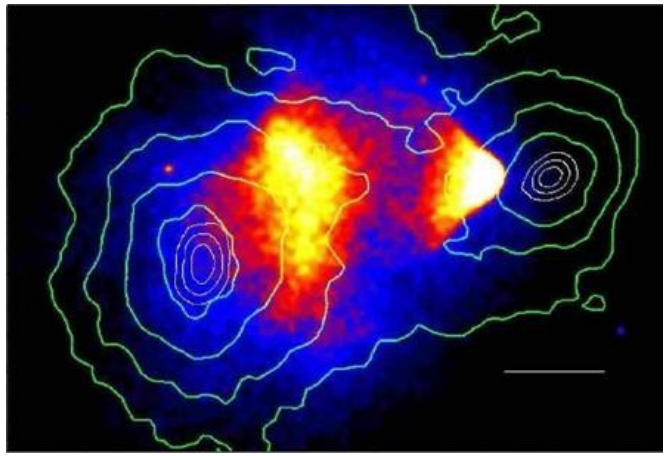
The model

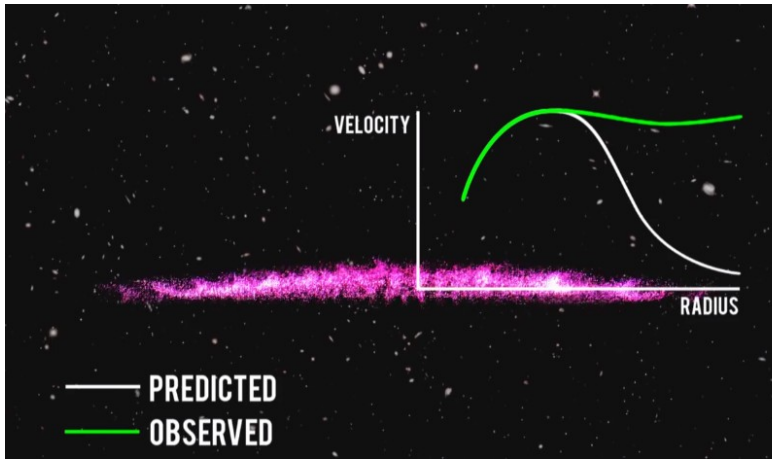
Conclusions

Based on *WIMP dark matter as radiative neutrino mass messenger*
M. Hirsch, R. A. Lineros, S. Morisi, J. Palacio, N. Rojas, J. W. F. Valle
JHEP 1310(2013)149 – arxiv:1307.8134

Dark Matter





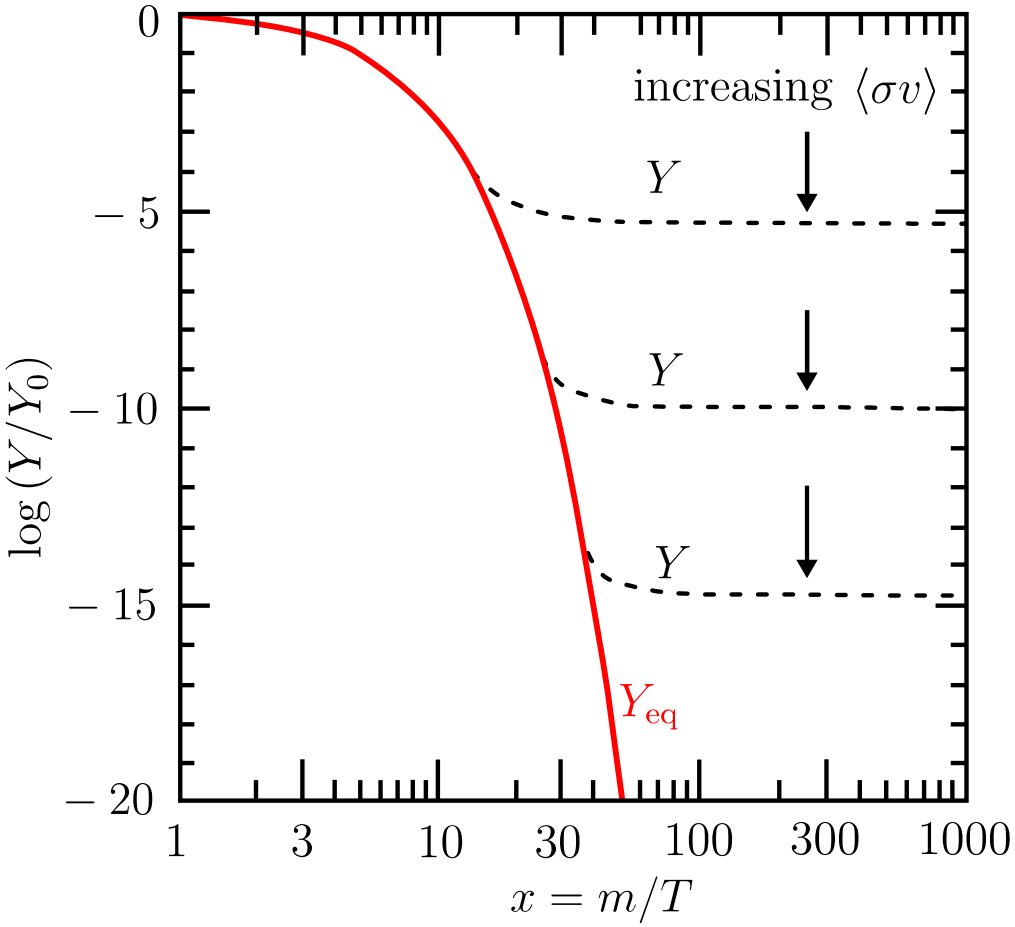


Observations support Dark Matter

- Dynamics of clusters and galaxies
- Structure formation
- CMB anisotropies
- Baryon Acoustic Oscillation

$$\Omega_{\rm DM} h^2 = 0.1196 \pm 0.0031$$

WIMP Dark Matter



Big Bang Thermal relic

Correct relic abundance for

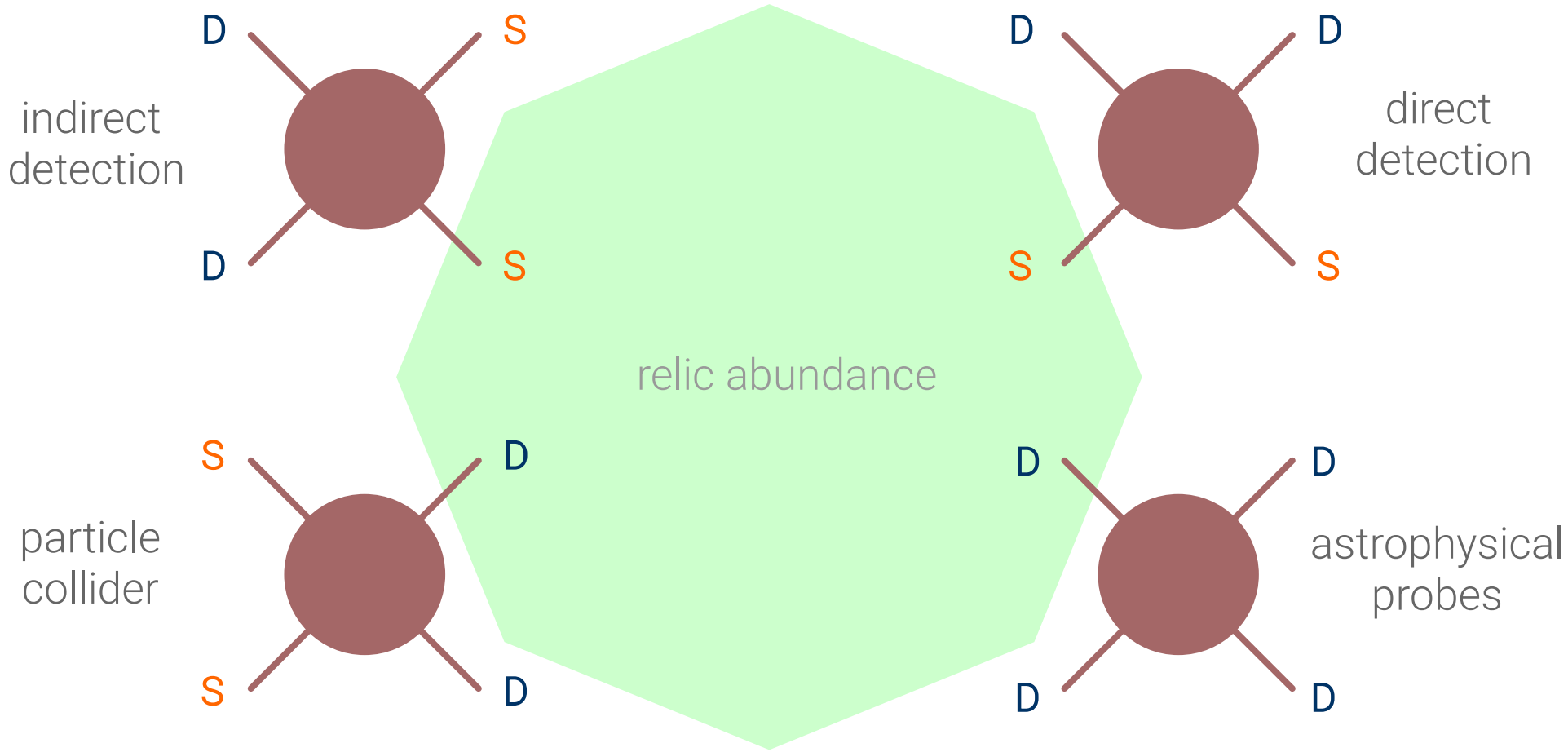
<σv> ~ 1 pb · c

Mass in GeV-TeV range

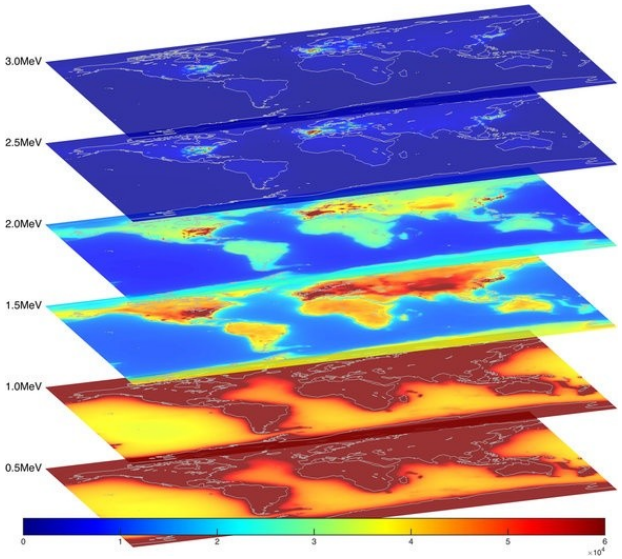
For WIMPs:

$$\Omega_{\rm DM} h^2 \simeq 0.1 \, \frac{3 \times 10^{-26}\,{\rm cm}^3/{\rm s}}{\langle \sigma v \rangle_{\rm f.o.}} \qquad T_{\rm DM}^{\rm f.o.} \simeq \frac{1}{20} m_{\rm DM}$$

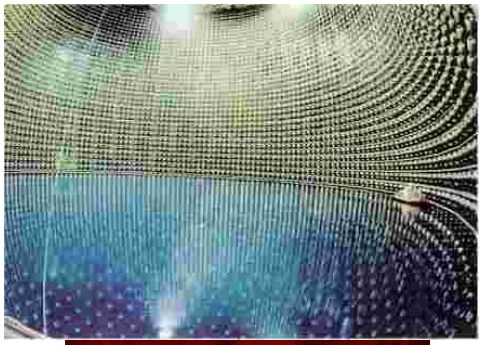
WIMP Searches



Neutrinos

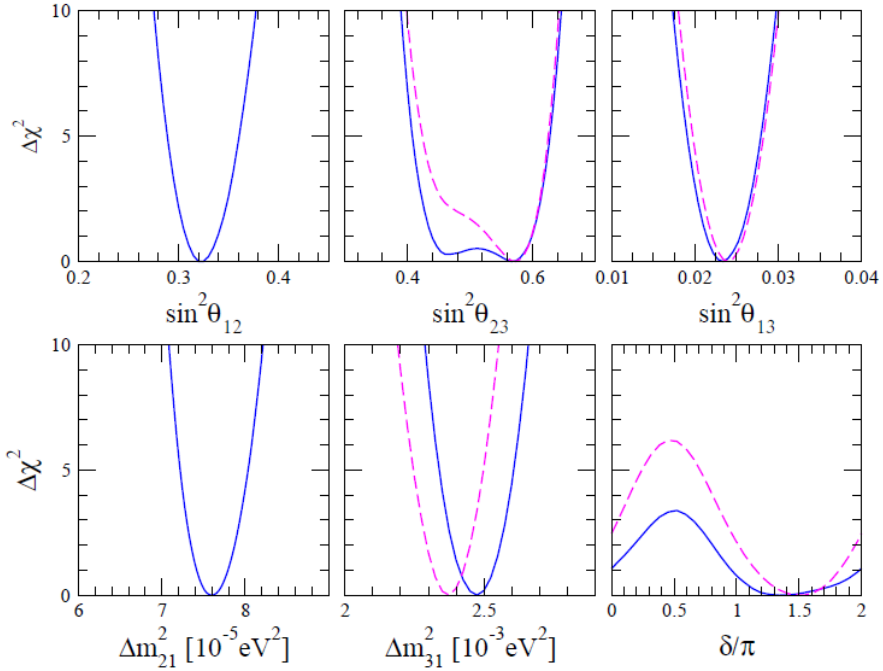


AGM2015: Antineutrino Global Map 2015



Super-K:
Neutrinos in the Sun

Forero, Tortola and Valle PRD 90 (2014) 093006

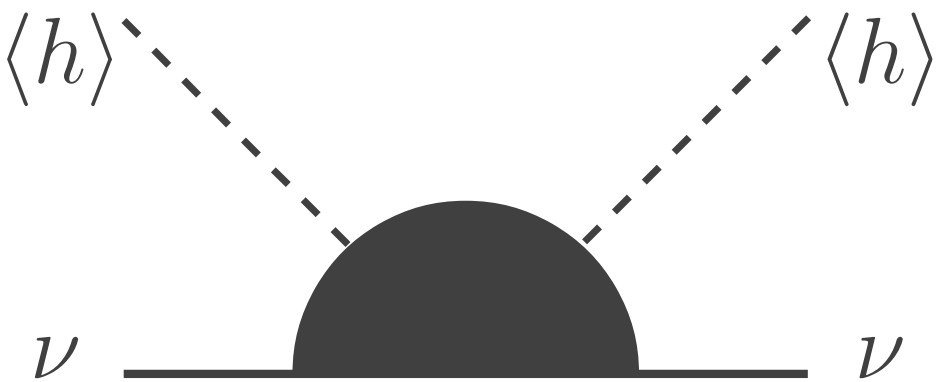


The SM predicted massless neutrinos

Physics beyond SM model is required to explain neutrino's mass spectrum and mixing angles

$$\mathcal{O}_5 \propto (L_i H)^T (L_j H)$$

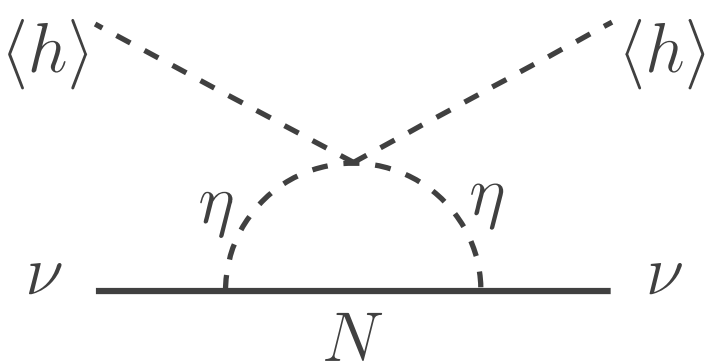
An old idea:



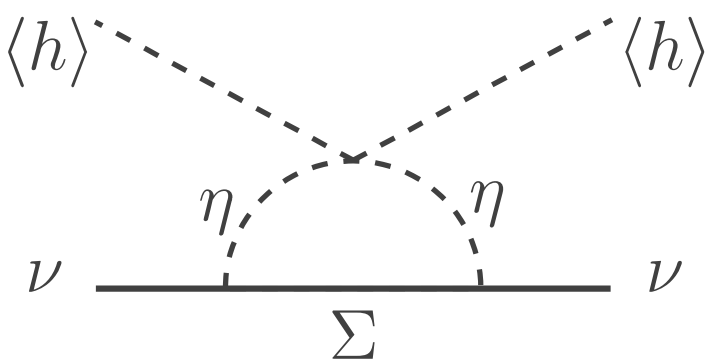
To connect neutrino mass mechanism and dark matter

(See Restrepo et al. JHEP arxiv:1308.3655)

We focus on scotogenic models:

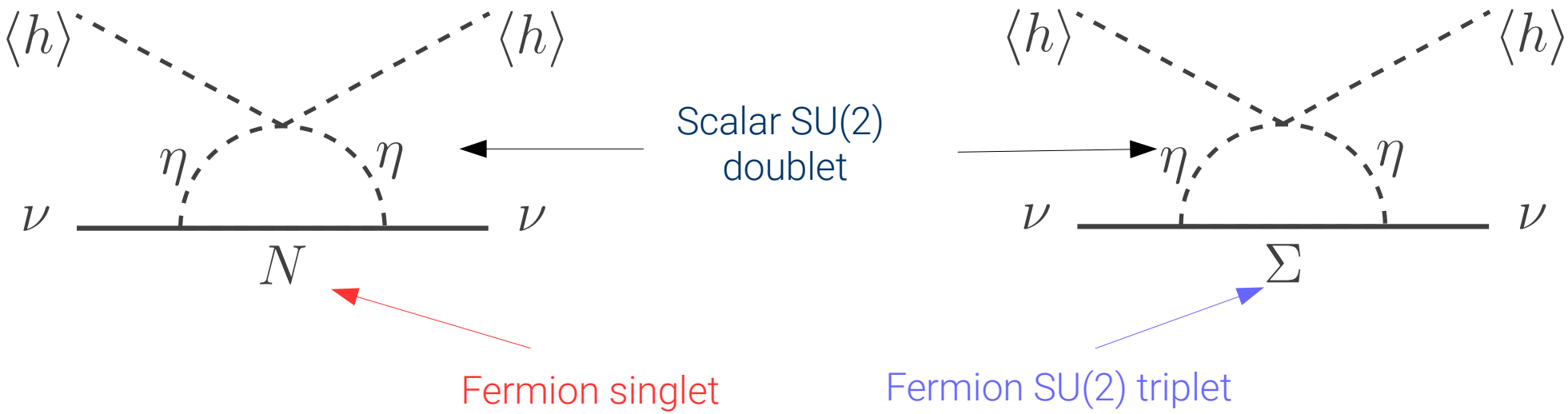


E. Ma, Phys.Rev.D73:077301,2006

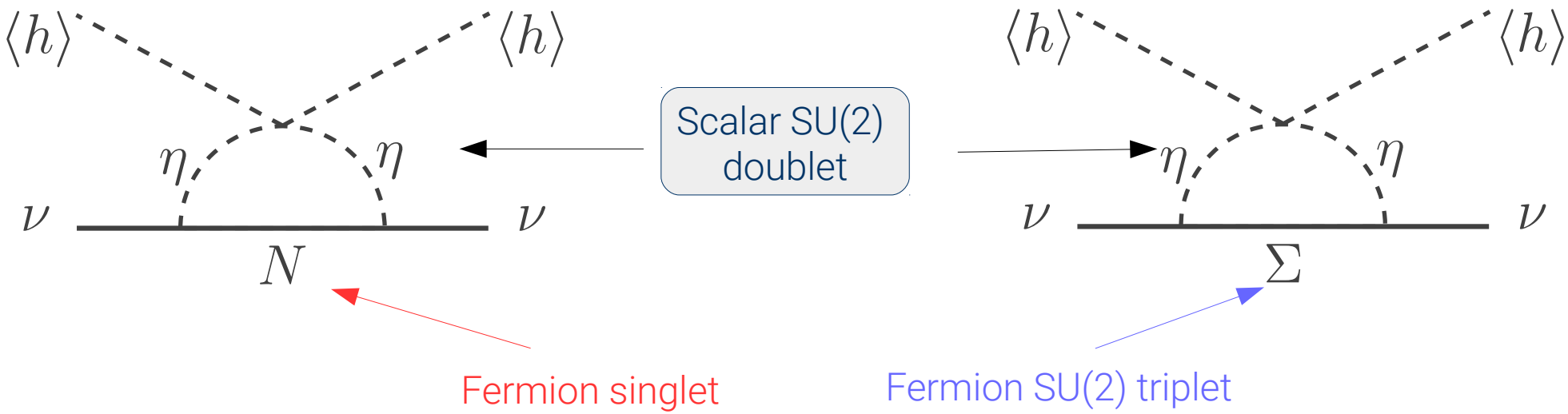


E. Ma, D. Suematsu Mod.Phys.Lett.A24:583-589,2009

Scotogenic models



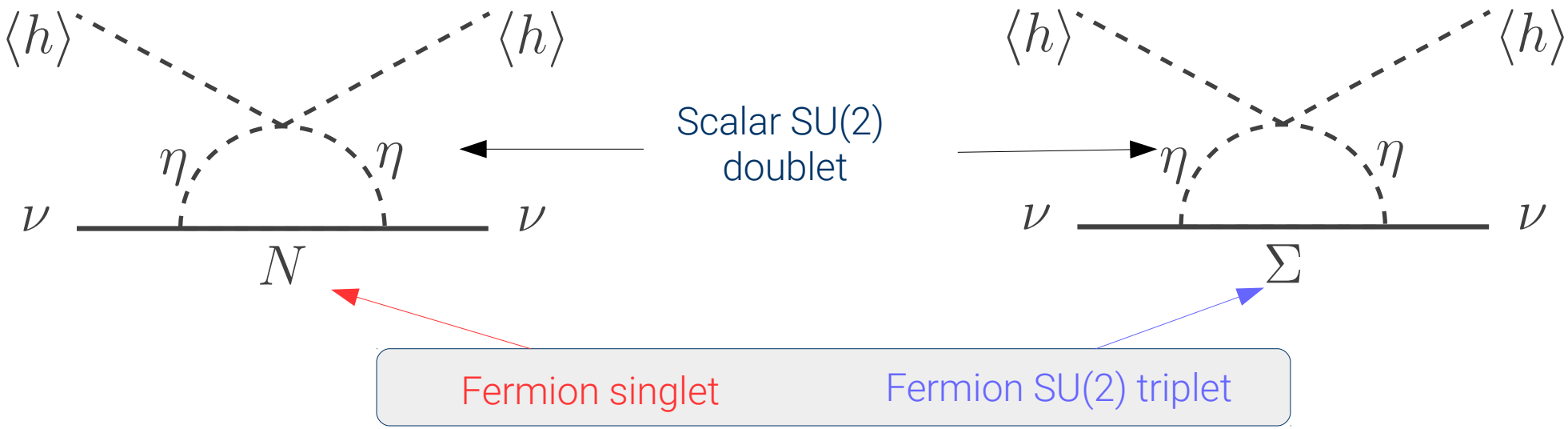
Scotogenic models



DM particle is scalar:

Phenomenology of the Inert Higgs DM

Scotogenic models



If DM particle is fermion:

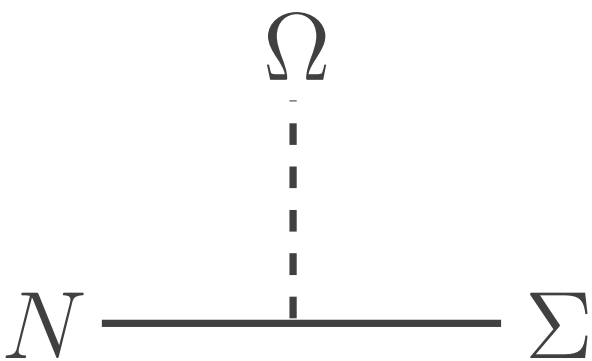
Annihilation into lepton, direct detection via loops,
DM mass < 50 GeV

Annihilation via Gauge interactions, direct detection via loops,
DM mass ~ 2.7 TeV Coannihilations dominate relic abundace(!)

The model

	Standard Model			Fermions		Scalars	
	L	e	ϕ	Σ	N	η	Ω
$SU(2)_L$	2	1	2	3	1	2	3
Y	-1	-2	1	0	0	1	0
Z_2	$+$	$+$	$+$	$-$	$-$	$-$	$+$

- Neutrino masses are generated at one loop
- Ω^0 acquires vev and mixes with SM higgs
- DM candidate is a mix of N and Σ^0



The model

$$\Sigma^0 \longrightarrow \chi_1^0 \qquad \Sigma^\pm \longrightarrow \chi^\pm$$

$$N \longrightarrow \chi_2^0$$

$$\Omega^0 \longrightarrow S_1^0 \qquad \Omega^\pm \longrightarrow S^\pm$$

$$h \longrightarrow S_2^0$$

Mixed states give phenomenology similar to electroweakinos

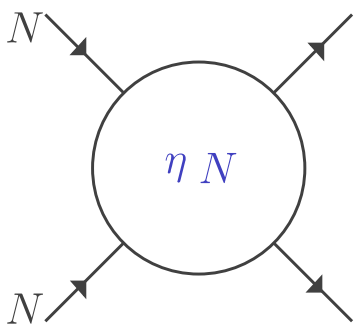
DM Mass spectrum

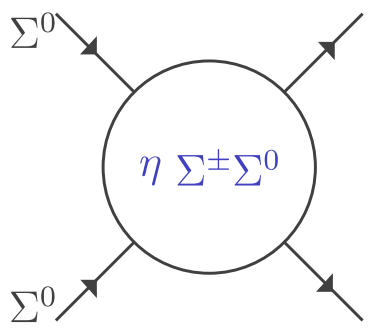
$$
\begin{aligned}
m_{\chi^\pm} &= M_\Sigma \,, \\
m_{\chi_1^0} &= \frac{1}{2}\left(M_\Sigma + M_N - \sqrt{(M_\Sigma - M_N)^2 + 4(2Y_\Omega v_\Omega)^2}\right) \\
m_{\chi_2^0} &= \frac{1}{2}\left(M_\Sigma + M_N + \sqrt{(M_\Sigma - M_N)^2 + 4(2Y_\Omega v_\Omega)^2}\right) \\
\tan(2\,\alpha) &= \frac{4Y_\Omega v_\Omega}{M_\Sigma - M_N} \,,
\end{aligned}
$$

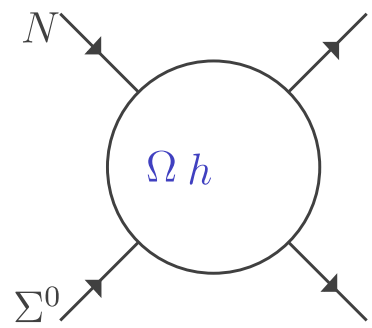
$$
\xi = \frac{M_\Sigma - m_{\rm DM}}{m_{\rm DM}}
$$

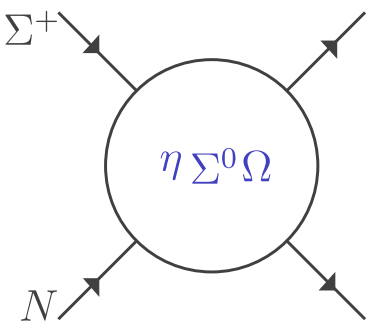
Mixing between N and Σ^0 depends on Ω^0 vev and couplings

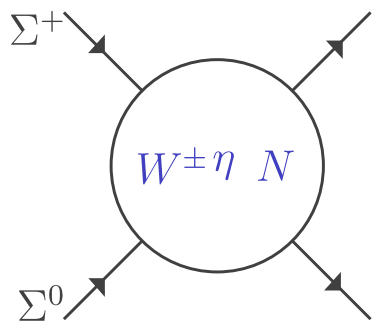
The processes

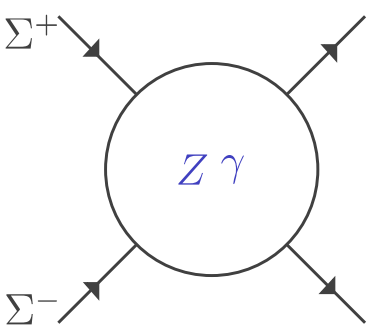








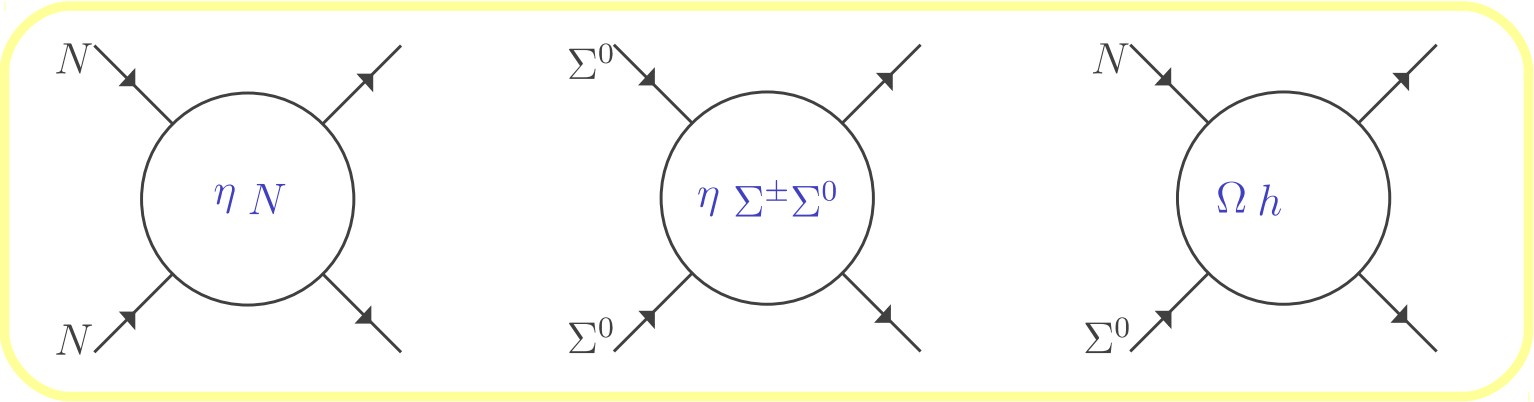




MicrOmegas

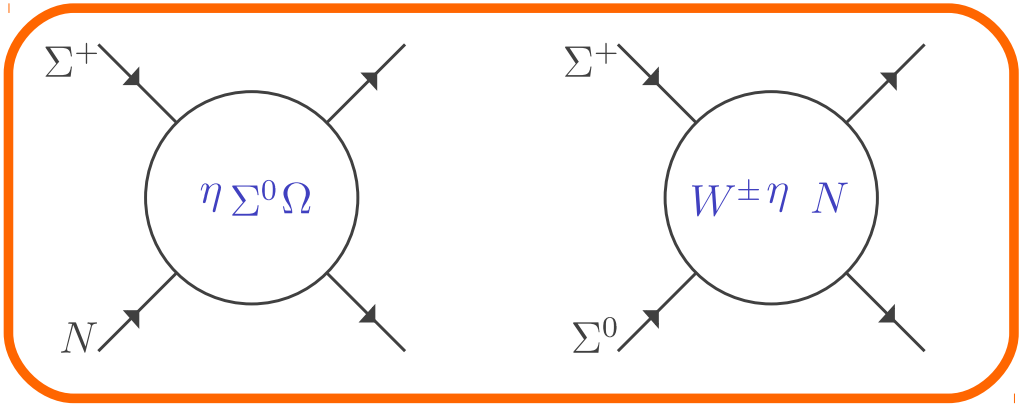
$$\Omega_{\rm DM} h^2 = 0.1196 \pm 0.0031$$

The processes

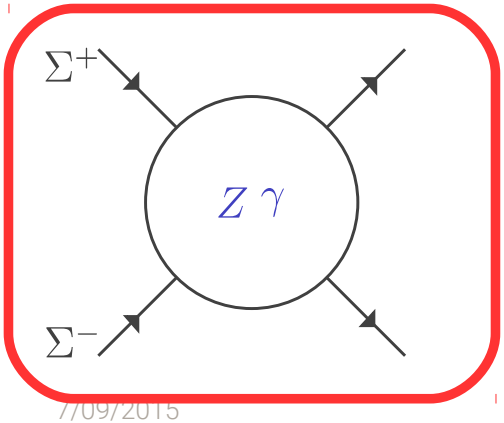


Annihilation

$l^+l^-\quad W^+W^-\quad q\bar{q}$



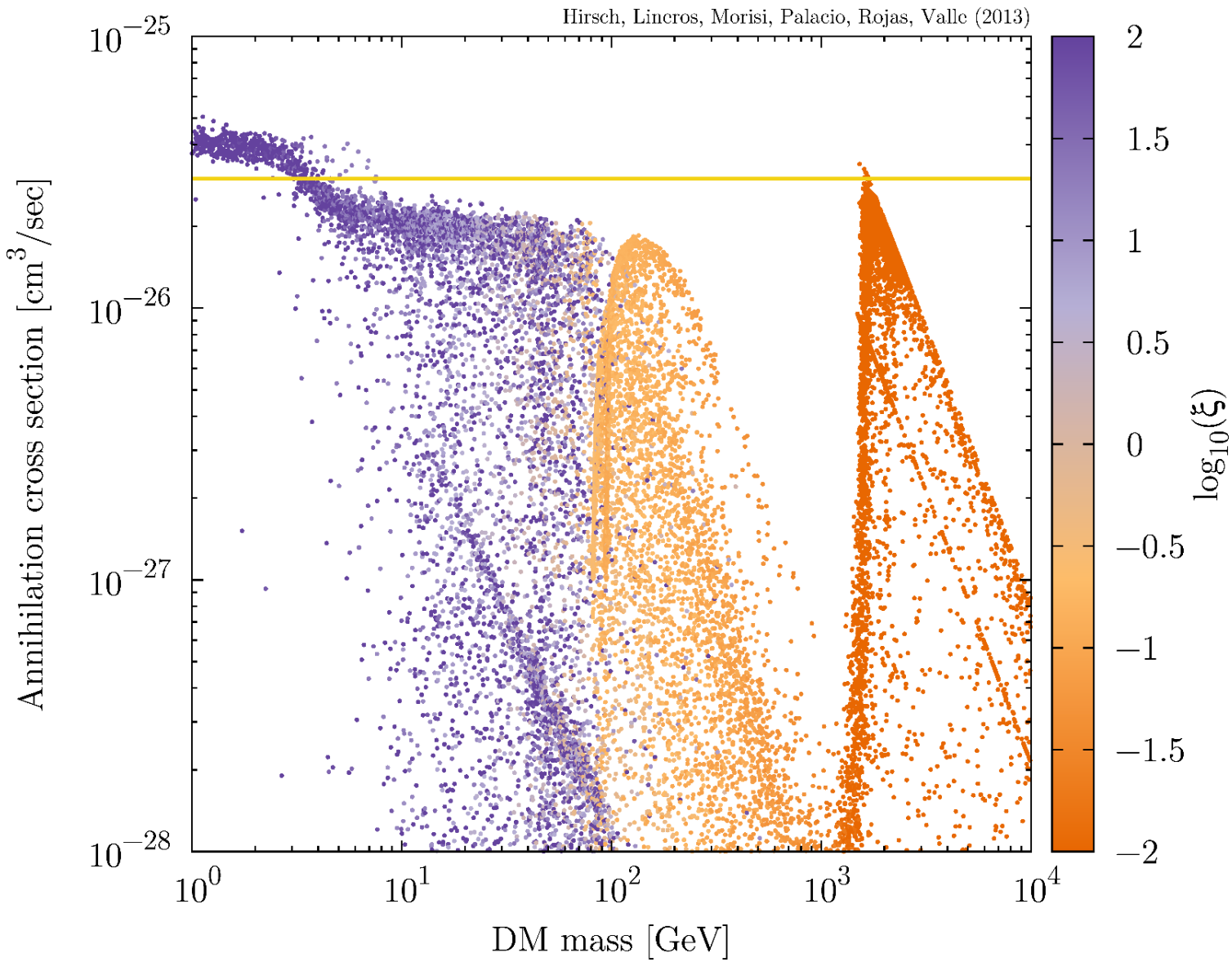
Coannihilation



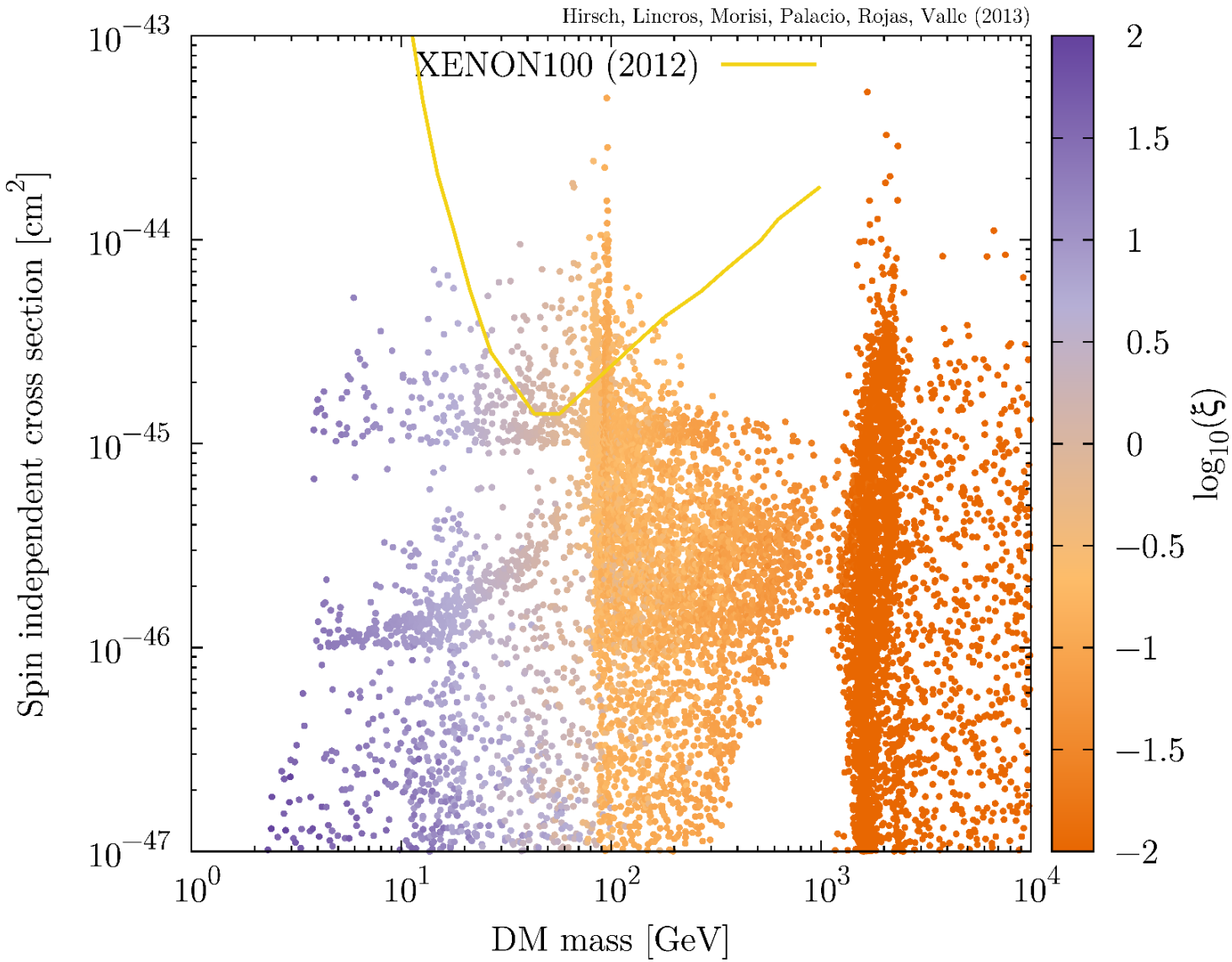
$\Sigma^{\pm}$ annihilation

m_{DM} ~2.7 TeV

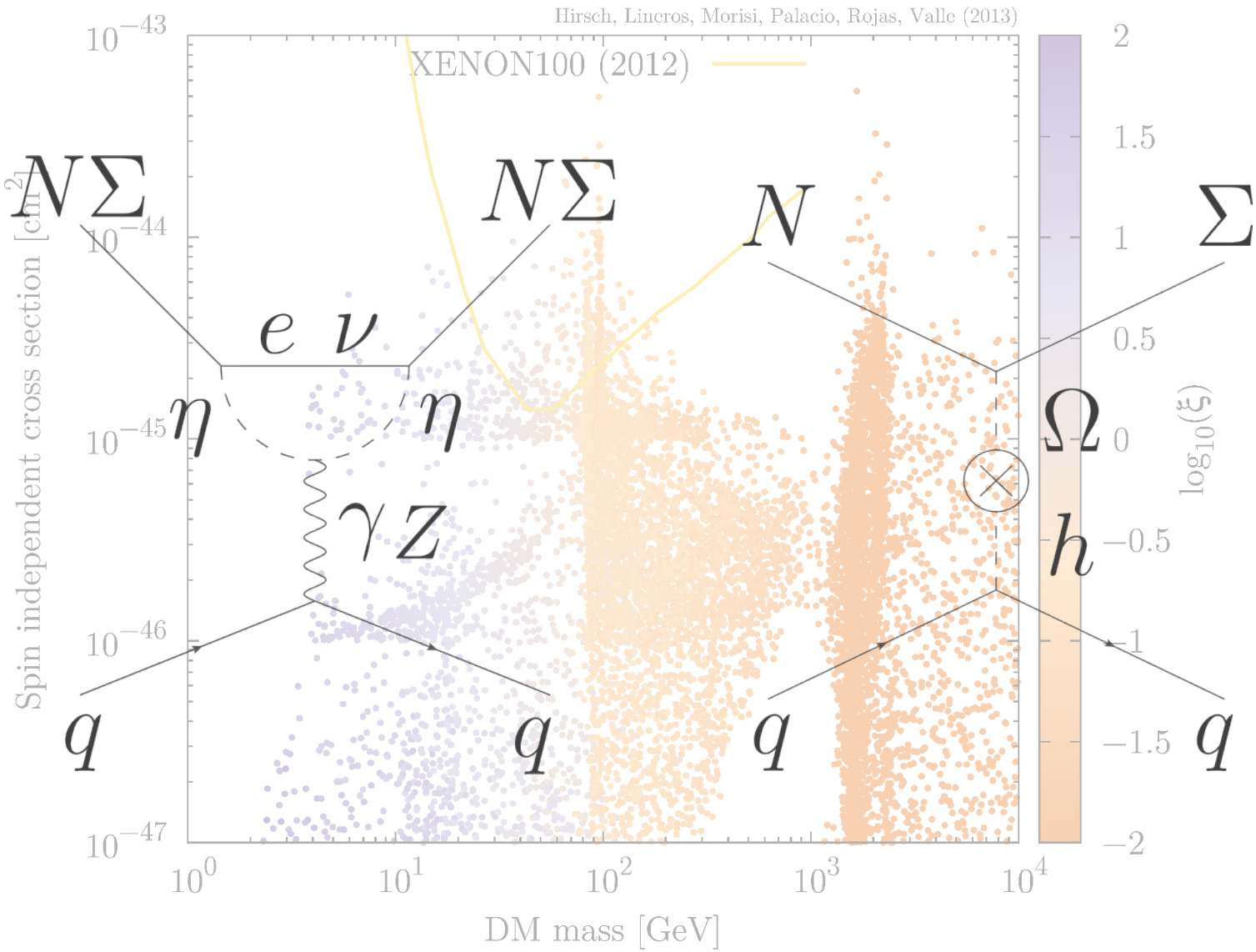
Annihilation cross section



Direct detection



Direct detection



Conclusions

Neutrino mass mechanism connected to DM is an interesting idea

In our model, DM signals couples to leptons and quarks as a generic WIMP

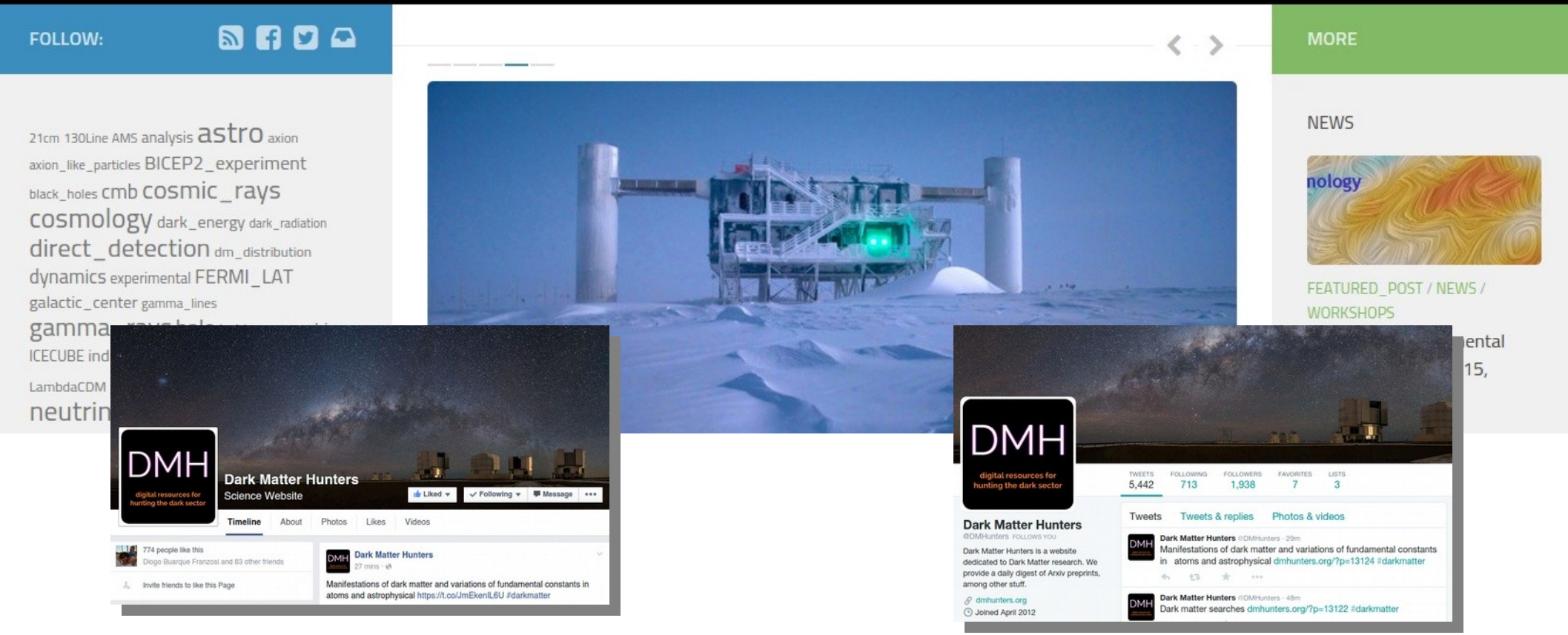
Direct detection cross section can be higher enough to be testable in current a future experiments (like LUX)

Due to its gauge interaction, searches at colliders are also possible (some similarity to electroweakinos)

Dark Matter Hunters

Digital resources for hunting the dark sector

www.dmhunters.org



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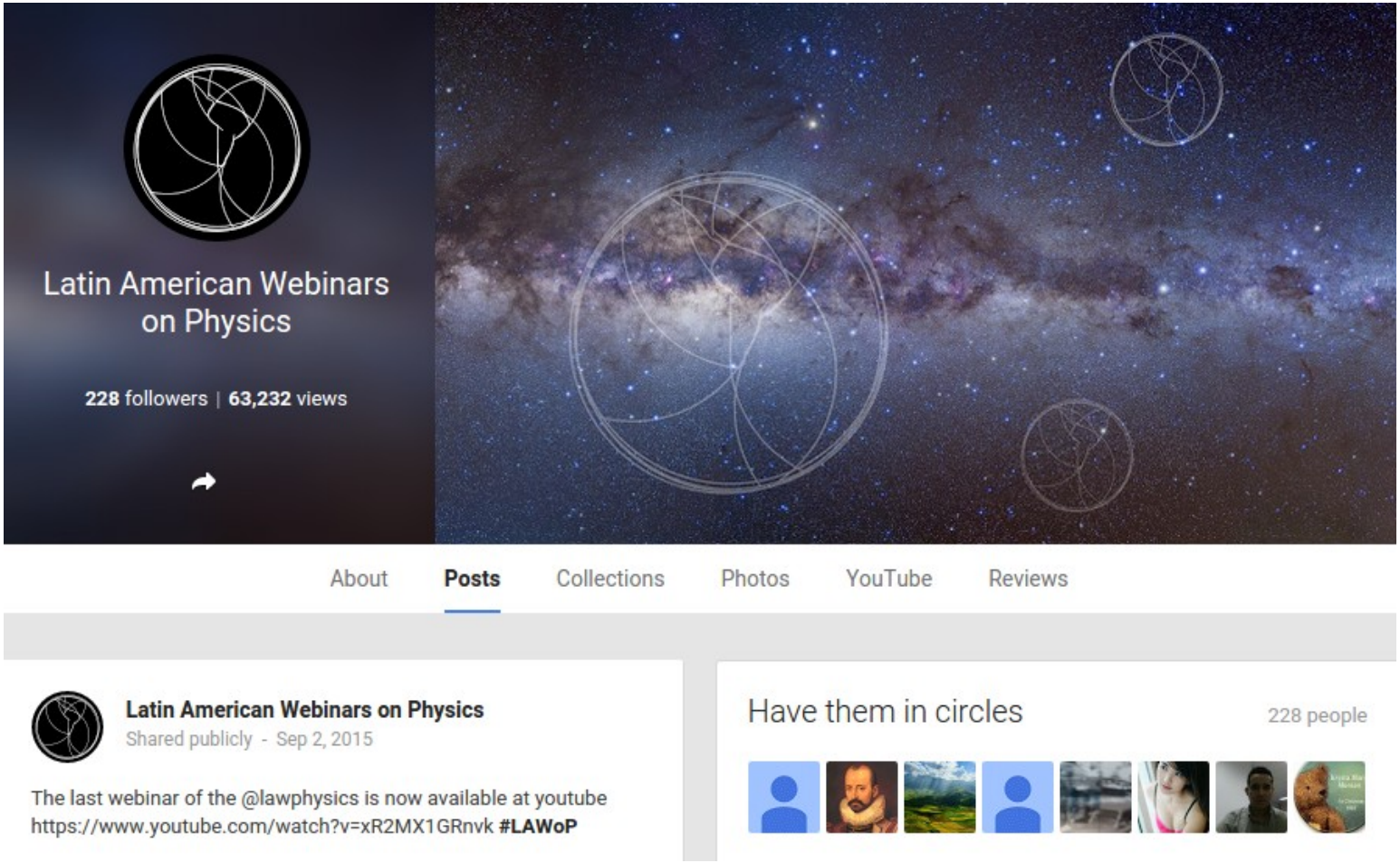

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Thank you