DM stability from non-Abelian discrete flavor symmetries

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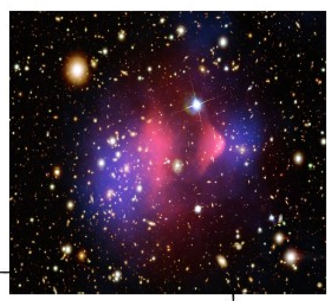
Dark Matter

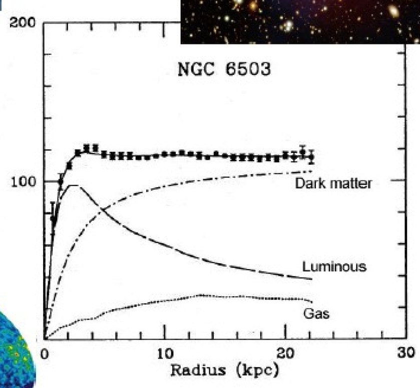
Cosmology & Astronomy :

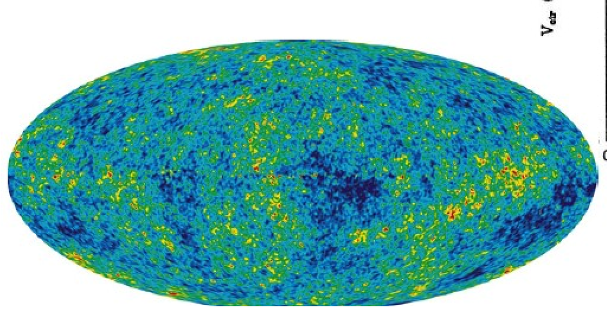
... 04% Ordinary Matter

... 23% Dark Matter

... 73% Dark Energy







DM must be also: neutral, cold, long-lived, ... stable (quite enough)

Bertone et. al. 040417, *Phys.Rept. 405 (2005) 279-390*
Taoso et. al. 0711.4996, *JCAP 0803 (2008) 022*

Ways to stabilize DM...

- discrete Z_2 of gauged $U(1)_{B-L}$ (R parity, GUT)
- accidentally (minimal DM, hidden vector DM)
- from gauged symmetries
- ...

T.Hambye 1012.4587

Flavour Symmetries

FS has been useful to relate masses and mixings for quarks and leptons since long ago.

For instance TBM mixing

$$U_{HPS} = \frac{1}{\sqrt{6}} \begin{bmatrix} & \nu_1 & \nu_2 & \nu_3 \\ \nu_e & 2 & \sqrt{2} & 0 \\ \nu_\mu & -1 & \sqrt{2} & -\sqrt{3} \\ \nu_\tau & -1 & \sqrt{2} & \sqrt{3} \end{bmatrix}$$

Harrison, Perkin and Scott

A4 useful to predict TBM

Altarelli and Feruglio

A_4 Symmetry

The generators are :

S and T $\quad S^2 = T^3 = (ST)^3 = \mathcal{I}.$

Z_2: $S = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

Z_3: $T = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$

$1,\ 1',\ 1''$ and 3

$1 \quad S=1 \quad T=1$

$1' \quad S=1 \quad T=e^{i4\pi/3}\equiv\omega^2$

$1'' \quad S=1 \quad T=e^{i2\pi/3}\equiv\omega$

The Model

SM + 3 Higgs SU(2) doublets , 4 right handed neutrinos

Hirch, Morisi, Peinado and Valle Phys. Rev. D 82, 116003 (2010)

	L_e	L_μ	L_τ	l_e^c	l_μ^c	l_τ^c	N_T	N_4	H	η
$SU(2)$	2	2	2	1	1	1	1	1	2	2
A_4	1	$1'$	$1''$	1	$1''$	$1'$	3	1	1	3

Dark matter candidate coupled only to heavy RH neutrinos

$1 \times 1_i = 1_i$
$1' \times 1'' = 1$
$1' \times 1' = 1''$
$1'' \times 1'' = 1'$

Z_3 — Charged leptons diagonal

All the higgses couple to the neutrinos

The alignment

$\langle\eta\rangle \sim (1,0,0)$

$S = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

Breaks spontaneously $A_4 \to Z_2$

$\langle\eta\rangle \sim (1,0,0)$

$H = \begin{pmatrix} \tilde{H}_0^+ \\ (v_h + \tilde{H}_0 + i\tilde{A}_0)/\sqrt{2} \end{pmatrix},\ \eta_1 = \begin{pmatrix} \tilde{H}_1^+ \\ (v_\eta + \tilde{H}_1 + i\tilde{A}_1)/\sqrt{2} \end{pmatrix}$ → Z2 even

$\eta_2 = \begin{pmatrix} \tilde{H}_2^+ \\ (\tilde{H}_2 + i\tilde{A}_2)/\sqrt{2} \end{pmatrix},\ \eta_3 = \begin{pmatrix} \tilde{H}_3^+ \\ (\tilde{H}_3 + i\tilde{A}_3)/\sqrt{2} \end{pmatrix}$ → Z2 odd → **Dark Matter Stability**

Scaling Matrix
Mohapatra and Rodejohann

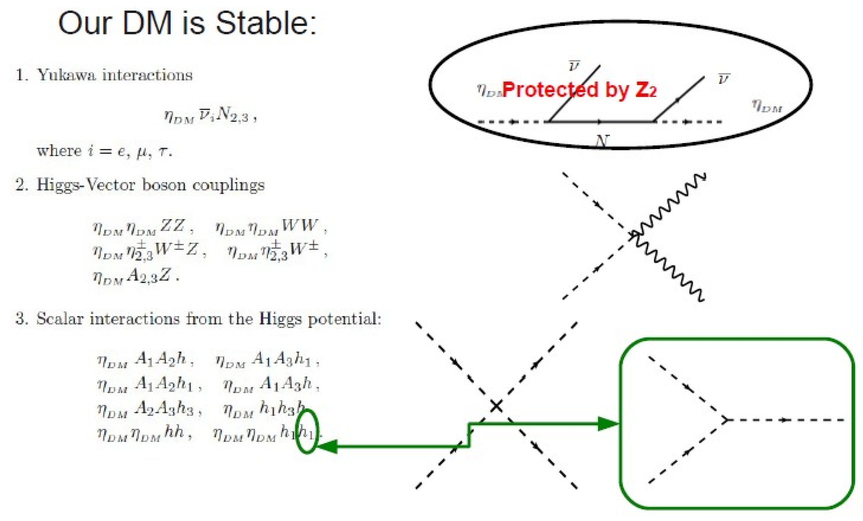
$\begin{pmatrix} y^2 & ab & ac \\ ab & b^2 & bc \\ ac & bc & c^2 \end{pmatrix} \quad \begin{pmatrix} 0 \\ -c/b \\ 1 \end{pmatrix}$

$m_3 = 0$

Inverse mass Hierarchy
$\{ m_{ee} \sim 0.03 - 0.05\ eV \}$

DM in the Model

Our DM is Stable:



Relic Density

WMAP
$0.09 \leq \Omega h^2 \leq 0.13$

Boucenna, Hirch, Morisi, Peinado, Taoso and Valle

MicrOMEGAs to compute relic density

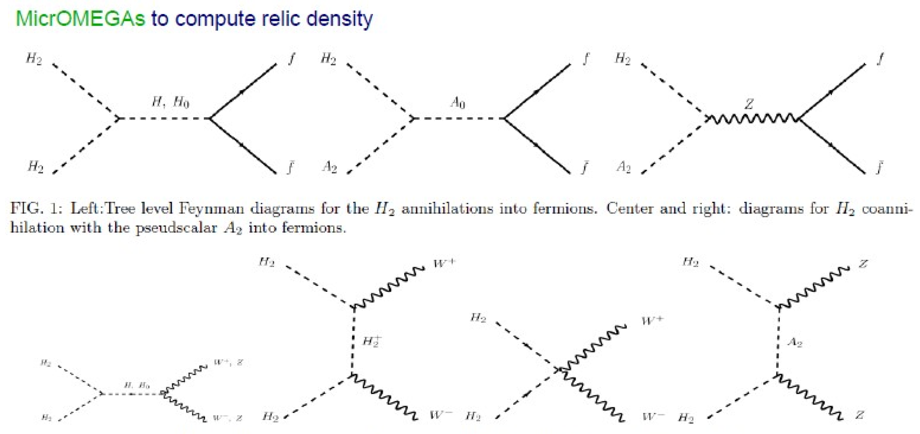
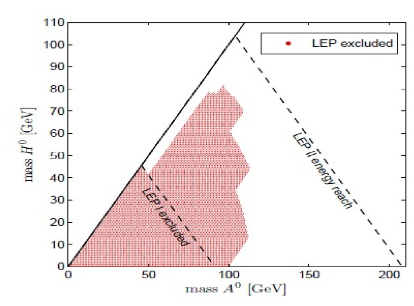
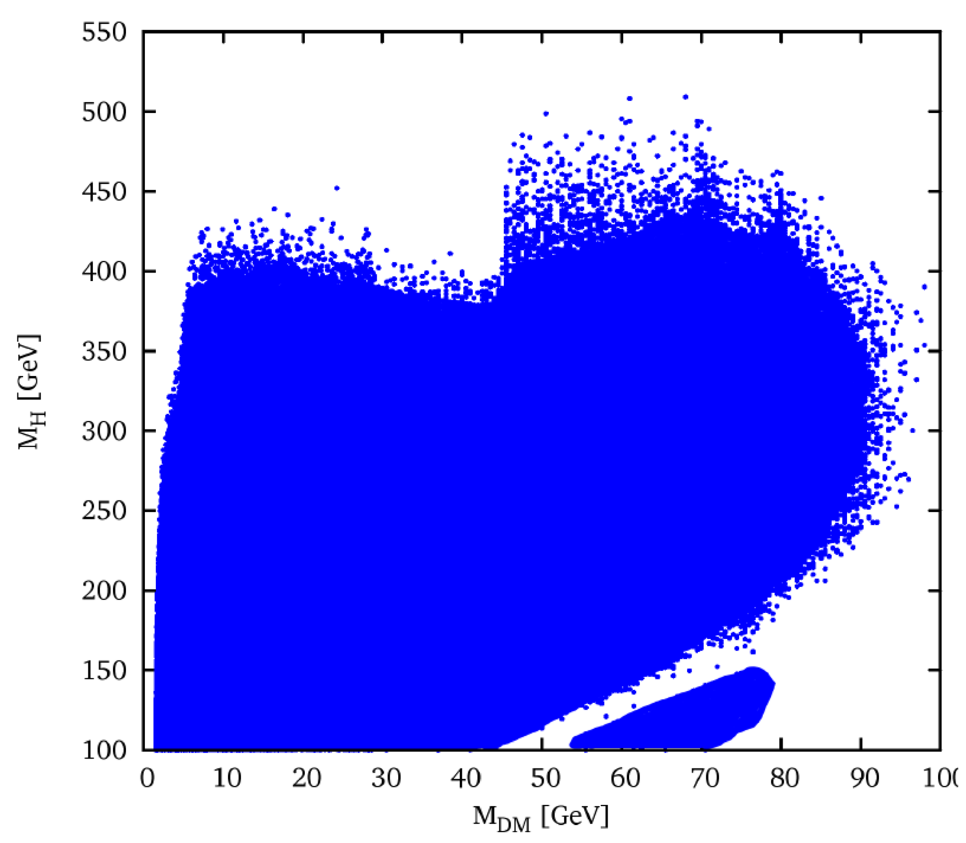


FIG. 1: Left:Tree level Feynman diagrams for the H_2 annihilations into fermions. Center and right: diagrams for H_2 coannihilation with the pseudoscalar A_2 into fermions.

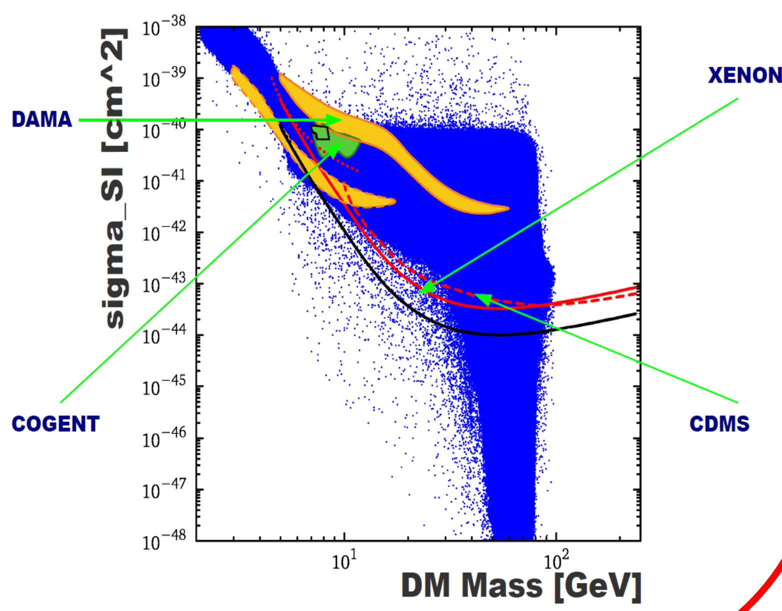
FIG. 2: Tree level Feynman diagrams for the H_2 annihilations into W^+ and Z Z.





Regions compatible with collider constraints and DM relic abundance compatible with measurements

Direct Detection



Conclusions

We propose a new mechanism to stabilize the DM and at the same time give some predictions for neutrino masses and mixings.

... It is consistent with Neutrino Phenomenology

... Predicts IH & vanishing theta13 $\quad m_3 = 0,\ \theta_{13} = 0$

... We found Regions compatible with Cosmology

... Direct detection possibilities.

Based on:

Hirsch, Morisi EP and Valle, PRD 82 (2010) 116030

Boucenna, Hirsch, Morisi, EP, Taoso and Valle, JHEP 1105 (2011) 037