

Dark matter in three-Higgs-doublet models with S_3 symmetry

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Particle physics is best described by the Standard Model. However, it fails to describe ... Possible solution: extend the scalar sector with interplay of symmetries.

Motivation: check S_3 -3HDM for Dark Matter candidates.

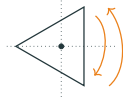
Main building block: $SU(2)$ scalar doublet, $\Phi = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix}$.

Re parameters (dependent) of NHDM [1007.1424]:

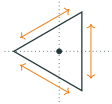
$$N_{\text{tot}} = \frac{1}{2}N^2(N^2 + 3) \rightarrow \begin{cases} N = 1 : & N_{\text{tot}} = 2, \\ N = 2 : & N_{\text{tot}} = 14, \\ N = 3 : & N_{\text{tot}} = 54, \\ \dots \end{cases}$$

Possible transformations of an equilateral triangle:

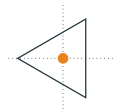
• 2 rotations



• 3 reflections



• Identity



S_3 irreducible representation: $\chi_1 \oplus \chi_{1'} \oplus \chi_2$.

S_3 -3HDM structure: $(\Phi_S)_1 \oplus \begin{pmatrix} \Phi_1 \\ \Phi_2 \end{pmatrix}_2$.

Symmetries reduce free parameters:

$$\text{NHDM} \xrightarrow{3\text{HDM}} (54) \xrightarrow{S_3} 12 \xrightarrow{\text{Re}} 10.$$

S₃-3HDM models were classified in **[1601.04654]**,

$$\text{vacuum: } (w_1, w_2, w_5) : [11] \text{ and } (\hat{w}_1 e^{i\sigma_1}, \hat{w}_2 e^{i\sigma_2}, \hat{w}_5) : [17].$$

Possible DM candidates: 3 (exact S₃) + 8 (softly broken) solutions.

Consider R-II-1a (0, w₂, w₅) vacuum configuration.

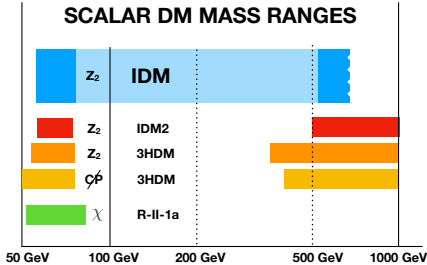
R-II-1a physical spectrum:

$$\Phi_1 [\text{dark/inert}] : \{h^\pm, \eta, \chi\} \quad \{\Phi_2, \Phi_5\} [\text{active}] : \{H^\pm, A, h, H\}.$$

Input parameters: 6 masses + 2 angles.

Several Cuts are applied:

- Cut 1: perturbativity, stability, unitarity checks, LEP constraints;
- Cut 2: SM-like gauge and Yukawa sector, electroweak precision observables, *B* physics;
- Cut 3 (micrOMEGAs **[0803.2360]**): $h \rightarrow \{\text{invisible}, \gamma\gamma\}$ decays, Γ_h , DM relic density, direct searches;

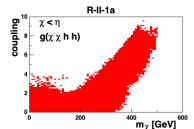
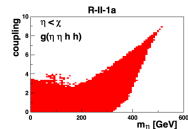
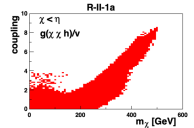
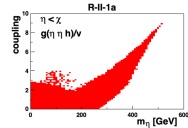
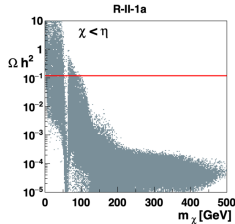
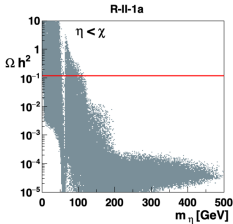


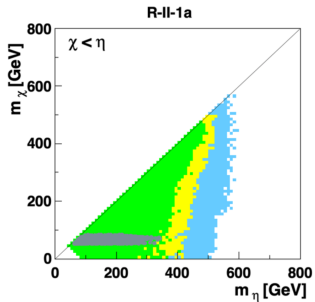
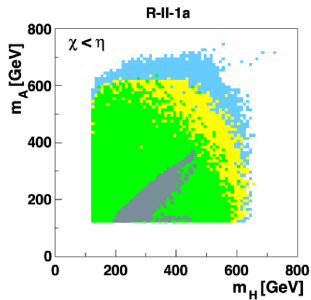
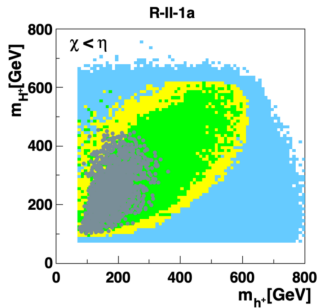
IDM: [1612.00511], [1809.07712];

IDM2: [1911.06477];

3HDM: [1407.7859],
[1507.08433], [1712.09598];

~~CP~~-3HDM: [1608.01673];





Conclusions

- Possible DM candidates were identified;
- Analysed the R-II-1a model numerically;
- Found a viable DM range [52, 84] GeV within R-II-1a;

Results can be found at **[2108.07026]**.

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