Scotogenic Models: Problems and Solutions

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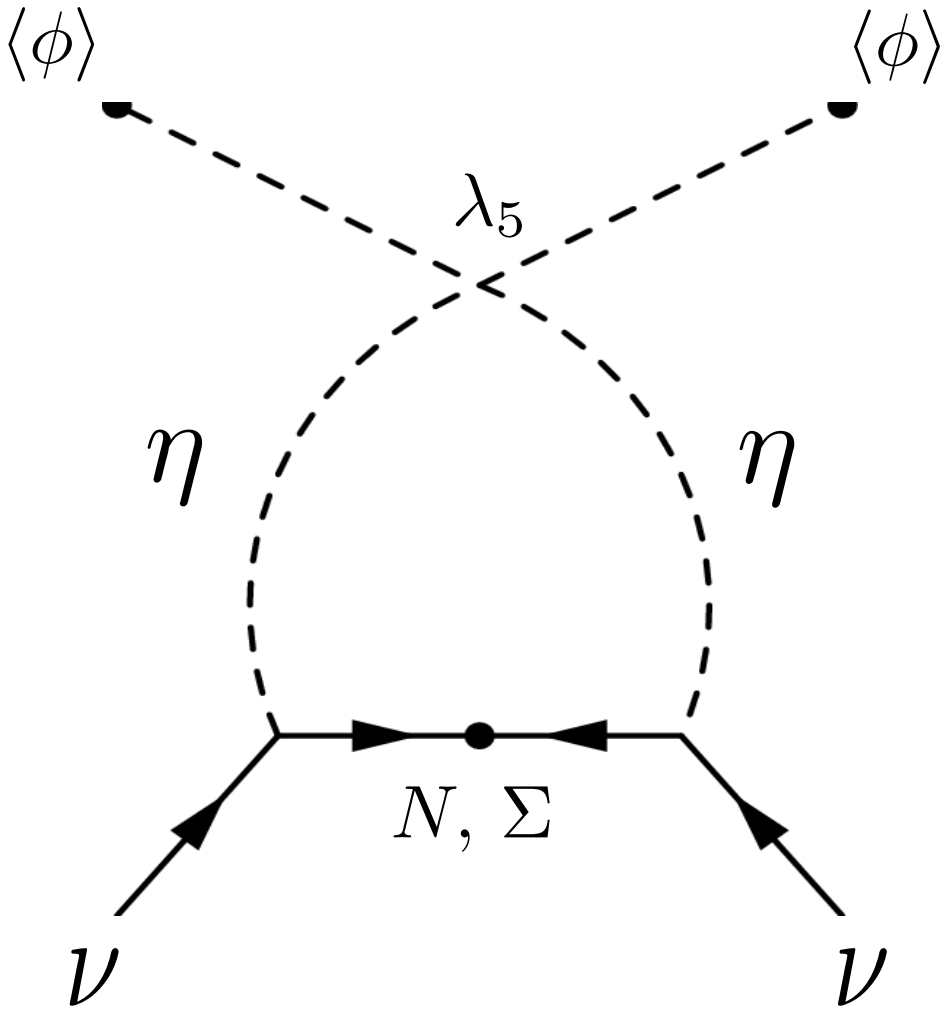
Introduction

- **Scotogenic Models:** Radiative generation of neutrino masses mediated by the DM candidate.

- We will focus on the radiative generation of neutrino masses via the loop in the right. There are other possibilities (Ma (2009), Fraser, Ma, Popov (2016)).

- Examples: Ma (2006). Ma (2008,2009). Hirsch, Lineros Morisi Palacio NR Valle (2013). Restrepo, Zapata, Yaguna (2013). Ahriche, McDonald, Nasri (2016). Yu (2016).



Basic Types.

- Singlet Scotogenic Model (SSM):

$$(\nu_i, l_i) \sim (2, -1/2; +), \quad l_i^c \sim (1, 1; +), \quad N_i \sim (1, 0; -),$$

$$(\phi^+, \phi^0) \sim (2, 1/2; +), \quad (\eta^+, \eta^0) \sim (2, 1/2; -).$$

Ma (2006). Kubo, Ma Suematsu (2006).

- Alternative: Triplet Scotogenic Model (TSM).

$$(\Sigma^+, \Sigma^0, \Sigma^-) \sim (1, 3, 0) \qquad (\eta^+, \eta^0) \sim (1, 2, 1/2)$$

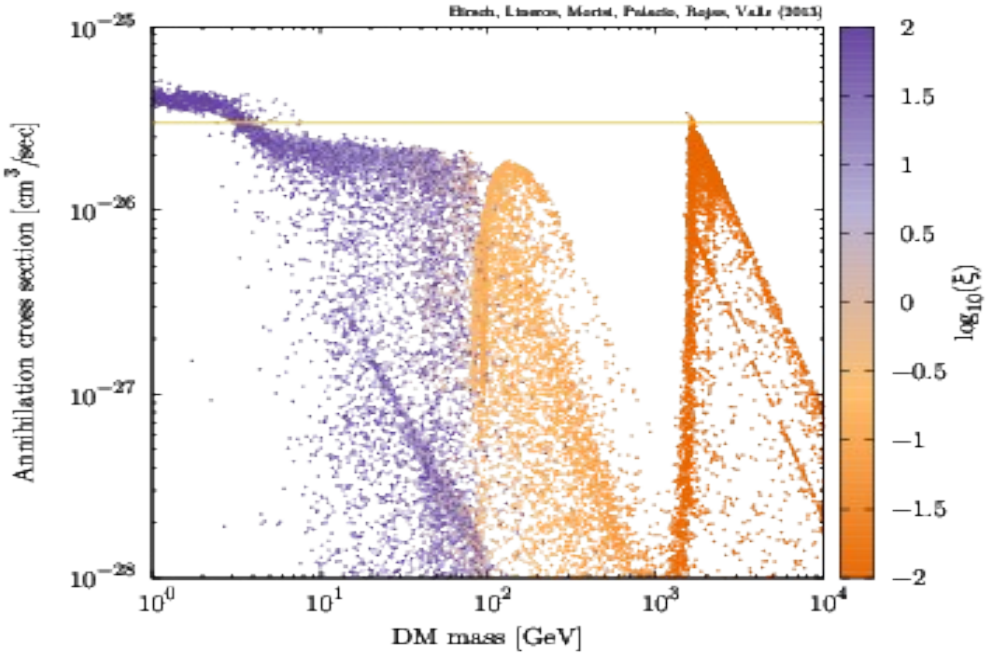
(Ma (2008))

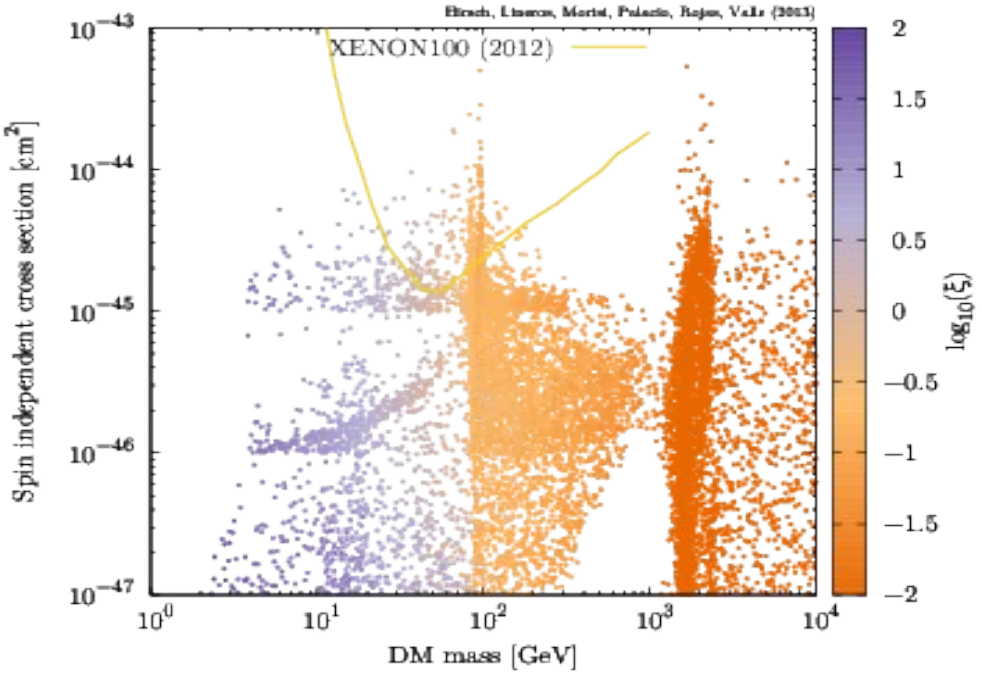
Singlet-Triplet Scotogenic Model

- The addition of just one gen. of singlet and one gen. of triplet will serve for: Radiative Neutrino masses, masses ranging from the EW scale to TeVs, and direct detection and production at colliders at tree level.

	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	+	+	+	−	−	−	+

Hirsch, Lineros, Morisi, Palacio, NR, Valle (2013).



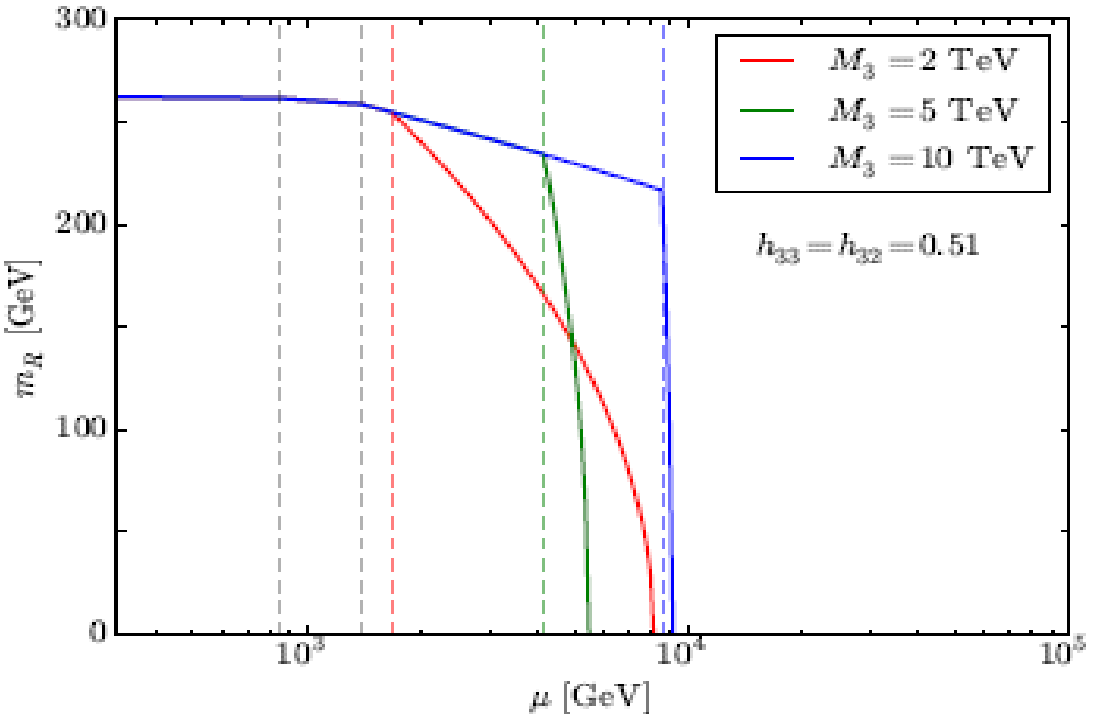


Z_2 Parity Breaking.

- In *SSM*, in the context of η like DM candidate, the running of the m_η^2 drives this parameter towards negative values.

$$\mathcal{D}m_2^2 = 6\lambda_2 m_2^2 + 2\left(2\lambda_3 + \lambda_4\right) m_1^2$$

$$+ m_2^2\left[2T_\nu - \frac{3}{2}\left(g_1^2 + 3g_2^2\right)\right] - 4\sum_{i=1}^{3} M_i^2 \left(h\,h^\dagger\right)_{ii}$$

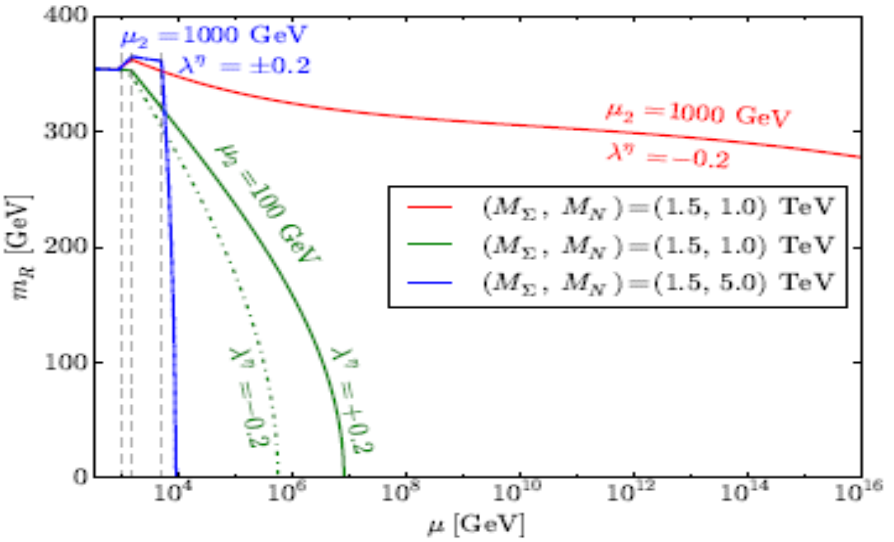


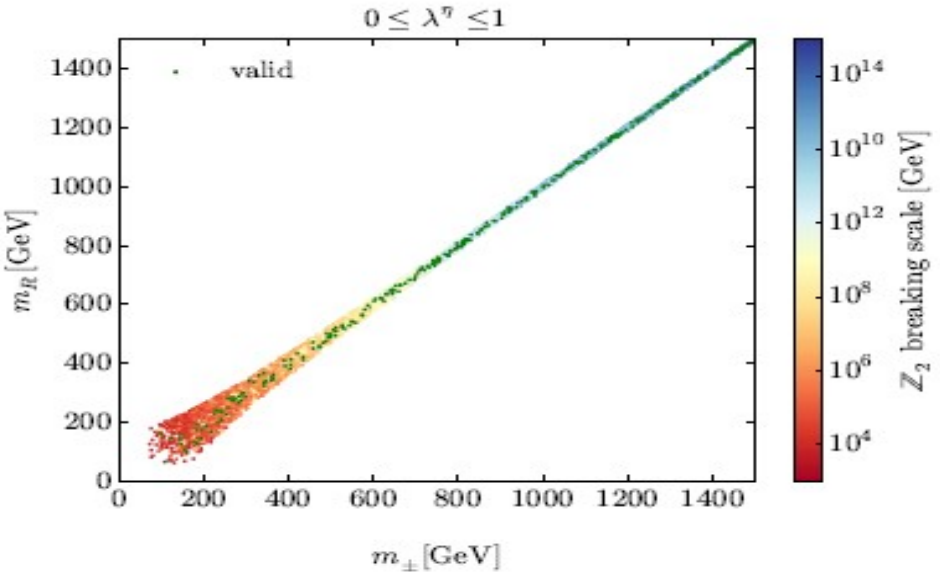
(Merle, Platscher (2015). Figures extracted from therein.)

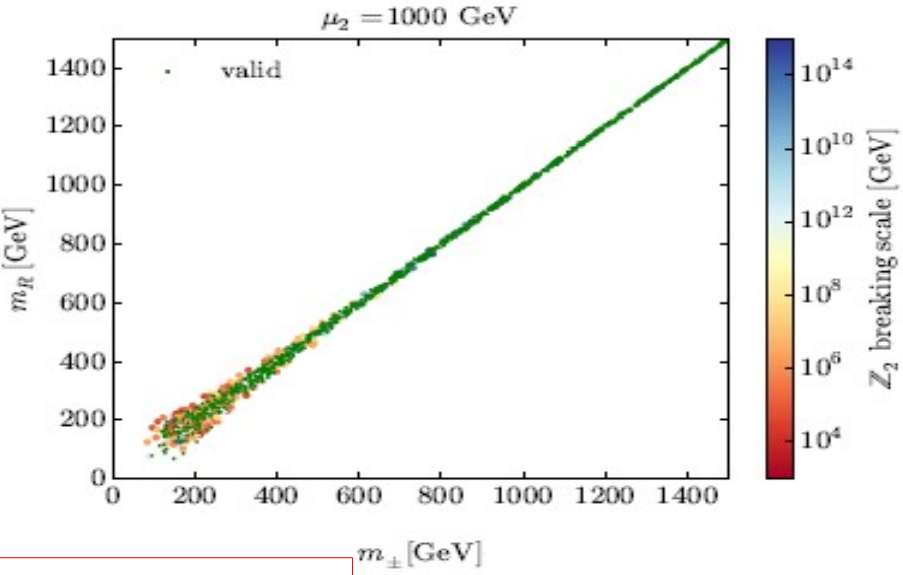
Z_2 Parity Breaking (II).

- Counteracted by effect of the scalar triplet @ STSM:

$$\beta_{m_\eta^2} \sim -3\lambda^\eta m_\Omega^2 + 3\mu_2^2 + \left(m_\eta^2 - 2|M_N|^2\right)\left(Y_N Y_N^*\right) + 3\left(m_\eta^2 - 2|M_\Sigma|^2\right)\left(Y_\Sigma Y_\Sigma^*\right)$$







(Merle, Platscher, NR, Vicente, Valle (2015).)

Conclusions

- Scotogenic Models: DM-mediated radiative neutrino masses.
- Basic flavors: SSM and TSM. In order to enrich phenomenology, the STSM was proposed.
- Mass parameters driven to negative values, potential breaking of the Z_2 parity in the context of scalar DM candidate.

Acknowledgements

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