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# Abelian gauge extensions with Higgs mixing

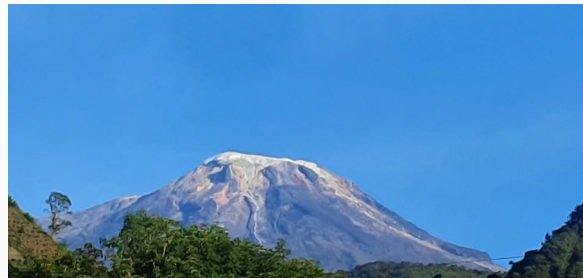
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In collaboration with

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and Carlos Yaguna (UPTC) [*In progress...*]



# Systematic study of the d=5 Weinberg operator at one-loop order

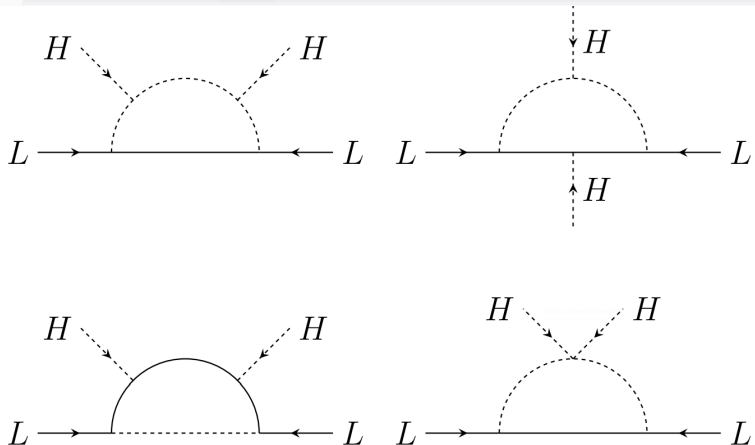
#1

Florian Bonnet (Wurzburg U.), Martin Hirsch (Valencia U., IFIC), Toshihiko Ota (Munich, Max Planck Inst.), Walter Winter (Wurzburg U.) (Apr, 2012)

Published in: *JHEP* 07 (2012) 153 • e-Print: [1204.5862](https://arxiv.org/abs/1204.5862) [hep-ph]

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Up to electro-weak triplets  
(Color singlets)

**Figure 1.** The four different 1-loop diagrams that can lead to genuine neutrino mass models [15].  
Top line: T-I-1 (left) and T-I-2 (right), bottom T-I-3 (left) and T-3 (right).

$$-i\Sigma_{ij}^{\nu}(p) = \int \frac{d^4k}{(2\pi)^4} (y_{in\alpha}) iS_F(k) (y_{jn\alpha}) i\Delta_F(p+k)$$

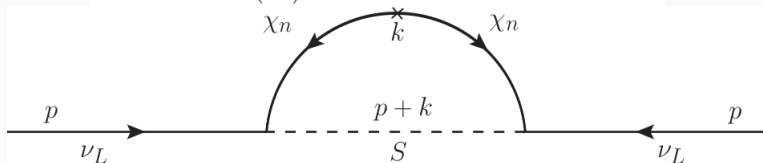


Figure 9.1: Generic one-loop neutrino mass contribution

$$M_{ij}^{\nu} = -\frac{y_{in\alpha}y_{jn\alpha}}{16\pi^2}m_{\chi_n} [\text{cte}(\infty) + f(m_{\chi_n}, m_{S_{\alpha}}^2)]$$

where

$$f(m_{\chi_n}^2, m_{S_{\alpha}}^2) = \frac{m_{S_{\alpha}}^2 \ln(m_{S_{\alpha}}^2) - m_{\chi_n}^2 \ln(m_{\chi_n}^2)}{m_{\chi_n}^2 - m_{S_{\alpha}}^2}$$

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# Hirsch-subindex → In the Acknowledgements section

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Pablo Escribano (Valencia U., IFIC), Jorge Terol-Calvo (IAC, La Laguna and Laguna U., Tenerife), Avelino Vicente (Valencia U., IFIC and Valencia U.) (Apr 8, 2021)  
Published in: *Phys.Rev.D* 103 (2021) 11, 115018 • e-Print: [2104.03705 \[hep-ph\]](#)  
"are eagerly awaited.18AcknowledgementsThe authors are grateful to **Martin Hirsch**, Farinaldo Queiroz and Moritz Platscher for fruitful discussions. They also ..."

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Pablo Escribano (Valencia U., IFIC), Avelino Vicente (Valencia U., IFIC and Valencia U.) (Aug 3, 2020)  
Published in: *JHEP* 03 (2021) 240 • e-Print: [2008.01099 \[hep-ph\]](#)  
"AcknowledgementsThe authors are grateful to Julian Heeck, Mario Reig and **Martin Hirsch** for fruitful discussions. Work supported by the Spanish grants FPA2017-85216-P ..."

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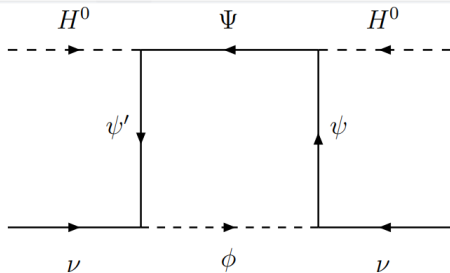
Diego Restrepo (Antioquia U.), Oscar Zapata (Antioquia U.), Carlos E. Yaguna (Munster U., ITP) (Aug 16, 2013)

Published in: *JHEP* 11 (2013) 011 • e-Print: [1308.3655](#) [hep-ph]

"Diego Aristizabal for helpful discussions. O.Z. is also very grateful to **Martin Hirsch** for his enlightening discussions. References[1] Planck Collaboration Collaboration ..."

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**Figure 3.** One-loop contribution to neutrino mass in the T1-3 models.

$\Psi$	$\psi'$	$\phi$	$\psi$
$1^F_\alpha$	$2^F_{1+\alpha}$	$1^S_\alpha$	$2^F_{\alpha-1}$

**Table 19.** Model T1-3-A.

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**Result: 35 models**

SARAH / Models / SSDM / SSDM.m 

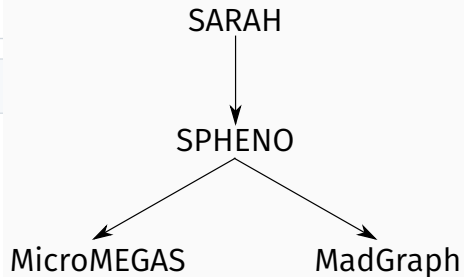
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Code

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4  Model`NameLaTeX ="Singlet scalar Dark Matter";
5  Model`Authors = "Diego Restrepo (based on SM model by F.Staub)";
6  Model`Date = "2015-11-16";
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# Radiative neutrino masses in the singlet-doublet fermion dark matter model with scalar singlets

Diego Restrepo(Antioquia U.), Andrés Rivera(Antioquia U.), Marta Sánchez-Peláez(Antioquia U.), Oscar Zapata(Antioquia U.), Walter Tangarife(Tel Aviv U.)

PHYSICAL REVIEW D **92**, 013005 (2015)

TABLE I.  $\alpha$  set of scalars and Weyl fermions of the model.

Symbol	$(\text{SU}(2)_L, \text{U}(1)_Y)$	$Z_2$	Spin
$S_\alpha$	$(1,0)$	—	0
$N$	$(1,0)$	—	1/2
$\tilde{R}_u,$	$(2, +1/2)$	—	1/2
$R_d$	$(2, -1/2)$	—	1/2

Like the MSSM bino-Higgsino sector (arbitrary couplings)

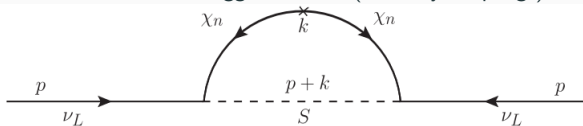


FIG. 1. One-loop Weyl-spinor Feynman rules [29] for the contributions to the neutrino mass, with three Majorana fermions ( $n = 1, 2, 3$ ) and a singlet scalar  $S$ .

The mass mixing must be taken into account to calculate the dark matter-nucleon scattering cross-section