I. README

This *Madgraph5* [1] package (STripletBaryogen_X2N1.tar.gz) is based on Ref. [2], a non-thermal production mechanism of ∼GeV dark matter that also mediates baryogenesis. The model adds two SU(3) triplet scalars X_1, X_2 and one Dirac fermionic dark matter n to the Standard Model. The new scalars' interaction terms with quarks and dark matter, and their couplings to gluons are implemented in this package. The *Madgraph5* model files are generated by *FeynRules* [3].

The new scalar's interaction derives from replacing one d^c superfield in the baryon number breaking SUSY trilinear term $u^c d^c d^c$ with the scalar X and the rest with their fermionic (SM) components. The interaction Lagrangian is,

$$\mathcal{L}_{int} = \lambda_1^{\alpha,\rho\delta} \epsilon^{ijk} X^*_{\alpha,i} \bar{d}_{\rho,j} \mathbf{P}_R d^c_{\delta,k} + \lambda_2^{\alpha,\rho} X_\alpha \bar{u}_\rho \mathbf{P}_R n + C.C. \tag{1}$$

where d^c is the charge-conjugate of the Dirac spinor. $\mathbf{P}_R$ is the right-handed projection operator. For the indices, $\alpha = 1, 2$ denotes the two X scalars, $\rho, \delta = \{1, 2, 3\}$ denote the three quark generations, and $i, j = \{1, 2, 3\}$ are the SU(3) color indices.

For coupling coefficients,

$$\lambda_1^{\alpha,\rho\delta} = \lambda_1 \cdot \lambda_{1X}^{\alpha} \cdot \lambda_{1R}^{\rho\delta}, \tag{2}$$

where λ_1 sets the overall scale of coupling strength and the latter two give the X and quark generation structures, naively assigned as:

$$\lambda_{1X}^{\alpha} = (1, 1) \qquad \text{and} \qquad \lambda_{1R}^{\rho\delta} = \begin{pmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}. \tag{3}$$

Note the $\lambda_{1R}^{\rho\delta}$ can not be symmetric because of the color coefficients being antisymmetric. Similarly,

$$\lambda_2^{\alpha,\rho} = \lambda_2 \cdot \lambda_{2X}^{\alpha} \cdot \lambda_{2R}^{\rho}, \tag{4}$$

where

$$\lambda_{2X}^{\alpha} = (1, 1) \qquad \text{and} \qquad \lambda_{2R}^{\alpha} = (1, 1, 1). \tag{5}$$

Here all three generations share the same couplings. In principle these couplings can have different values among them. Modification on the generation structure can be done by

changing the $\lambda^{\alpha}_{X/R}$ values in the mg5 model file *parameters.py*. Note *param_card.dat* does not take $\lambda^{\alpha}_{X/R}$ as input parameters.

In Ref. [2], baryogenesis requires more than one new scalars, so in the package two such scalars are introduced. Yet I artificially made one much heavier than the other, hence only the lighter scalar is relevant for phenomenology at the LHC. For proton stability, the dark matter n must be very close to proton mass, and is set to 0.938 GeV. The $\lambda_{1,2}$ coefficients are set to 0.1.

ATTENTION: the scalar widths are dependent on the scalar mass, the coupling values and number of decay channels. Correct values of WX1, WX2 must be set in either *parameters.py* and/or *param_card.dat* if the couplings or masses are changed.

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[1] J. Alwall, M. Herquet, F. Maltoni, O. Mattelaer and T. Stelzer, JHEP **1106**, 128 (2011) [arXiv:1106.0522 [hep-ph]].

[2] R. Allahverdi and B. Dutta, Phys. Rev. D **88**, 023525 (2013) [arXiv:1304.0711 [hep-ph]].
see also R. Allahverdi, B. Dutta and K. Sinha, Phys. Rev. D **82**, 035004 (2010) [arXiv:1005.2804 [hep-ph]].

[3] N. D. Christensen and C. Duhr, Comput. Phys. Commun. **180**, 1614 (2009) [arXiv:0806.4194 [hep-ph]].