Baryogenesis in Mirror Twin Higgs

Linda Yuan

University of Toronto
with Gonzalo Alonso Alvarez, David Curtin, Andrija Rasovic

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Motivation

- Hierarchy problem, no SUSY found at LHC.
- Mirror Twin Higgs (MTH) evades LHC bounds through a color neutral top partner. A hidden sector is generated through μ_2 symmetry.[1]
- Asymmetric reheating mechanism ensures that i_{eff} bounds are satisfied.[2]
- Baryogenesis in MTH: μ_2 symmetry implies twin baryogenesis.
- Atomic Dark Matter (ADM) has interesting astrophysical implications.[3][4]
- Main question: what does SM baryogenesis imply about mirror sector baryogenesis, and hence atomic dark matter content of universe?

[1] µu G\9HcnJ [u]~u Wn\J 9jL |u [9}j_cJ r©··£s 9}±_®I ·U·£©U£
[2] µu G\9HcnJ iu G}9_XJ pu `u Sn²J 9jL |u [9}j_c r©·o¢s 9}±_®I o£oou·¢k¢U
[3] 8u W\9e 9 _ 9jL gu gHw«_jj r©·oPs 9}±_®I o¢o©u·V¢¢k
[4] `u S9jJ 8u b9§¶J du |9jL9eeJ 9jL gu |OOHO r©·o¨s 9}±_®I o¨·¨uoU©o

Mirror Twin Higgs Review

The hidden sector (denoted B) is a mirror copy of the SM sector (denoted A).

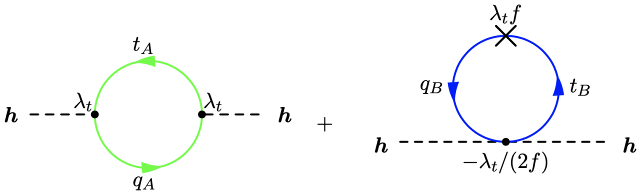
$$\sim^{a}(3)_{8} \quad \sim^{a}(2)_{8} \quad {}^{a}(1)_{8} \quad \overset{\mu_2}{!} \quad \sim^{a}(3)_{?} \quad \sim^{a}(2)_{?} \quad {}^{a}(1)_{?}$$

μ_2 symmetry ensures cancellation of quadratic divergences.

Twin vev higher than SM vev ⊺ > ®, [$_?$ heavier than [$_8$.

3 < ⊺ =® < 10 satisfies Higgs coupling constraints and avoids sub-percent tuning.

i_{eff} 6 → need asymmetric reheating or fraternal twin Higgs (hard μ_2 breaking to remove light degrees of freedom)[5]



S_X«}0I Wu ?«}Lh9j 0§ 9eu r©·oUs 9}±_®IoVoou¨¨o·

[5] i u G}9_XJ 8u b9§¶J g u ~§}9 e0}J 9jL |u ~«jL}«h r©·oUs 9}±_®I oU·ou·U¨o·

J h >

A M i ` Q / m + 2 b ` B ; ? i @ ? LM / 2M/LM 2 m i ` B M Q b

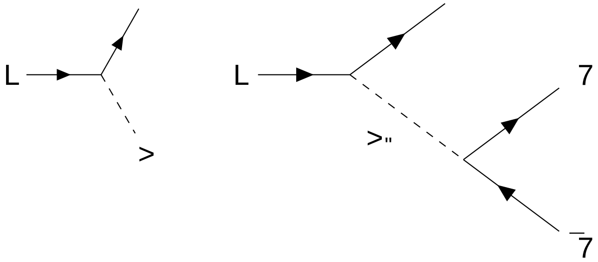
: 2 M 2 ` i 2 b + i B p 2 M 2K m = i ` B M Q M K # b Q i ? b 2 + i Q ` b

L_R B b H Q M ; @ H B p 2 / K b b 2 B ; 2 M b i i 2 i ? i 7 ` 2 2 x 2 b Q m i ` 2

T 2 ` B Q / Q 7 K i i 2 ` / Q K B M i B Q M - / 2 + v b 7 i 2 ` i r Q b 2 + i Q ` b /

K Q ` 2 i ? M "

" ` M + ? B M ; ` i B Q B M = i Q " b 2 7 + i H Q H / 2 + v b ` 2 i ? ` 2 2 @ # Q / v



bvKK2i`B+ _2?2 iBM; US`2HBKBM `vV

1M2`;v /2MbBiv ?BbiQ`v 7Q` QM2@;2M2` iBQM `2?2 iBM;X

L277+QMiQm`b 7Q` 7fp48 BM i?2 T ` K

Q7 `2?2 iQM K bb M/ `2?2 iBM; i2K

AMi2`2biBM; :2o<B QKL<R9yyy2o, yR /m2 iQ //BiBQM H irQ

i?`22@#Q/v /2+ v UMQi /Bb+mbb2/ ?2`2 #mi bF K2 7Q` /

KL > :2obQ rBHH ? p2 iQ ;2M2`2i2 i?2 HB;?i2bi +iBp2 M2r

" `vQ;2M2bB b>BM

J BM B/2 , L /2+ vb iQ ;2M2` i2 # `vQM MmK#2` pBQH iB
qAJS # `vQ;2M2bBbVX

h?2 `2??2 iQM K v Q` K v MQi #2 i?2 ;2M2` iQMX

h?2 ;2M2` iQM ? b iQ #2 +QmTH2/ iQ [m `F2 KM$_{;2M}$X +QHQ`

K$_{;2M}$ > K > 8yy:2o 7`QK G>* #QmM/ 7Q` +[e]QHQ`2/ b+ H `X

J Q / 2 H

A M i ` Q / m + 2 7 Q H H Q r B M ; B M i 2 ` + i B Q M b B M i ? 2 G ; ` M ; B M

$$L \quad v > G L \quad L \quad l \quad {}^{0} . \quad . \quad {}^{y}$$

$$v" >" G L" \quad " L" \quad " l " \quad {}^{0}_{"} . " . " \quad {}^{y}_{"}$$

q 2 / / T ` i B + H 2 + Q M i 2 M i

J m H i B T a H (2) i	a l(j)	a l(k)	l (R)	a l(j)"	a l(k)"	l (R)"
	j	R	@ k f j	R	R	y
"	R	R	y	j	R	@ k f j
L	R	R	y	R	R	y
L"	R	R	y	R	R	y

J b b 2 B ; 2 M b i i 2 b M / 2 B ; 2 M p H m 2 b

$$L = \frac{R}{\sqrt{k}} (L \quad L") ; \quad J = K_L \quad K"$$

Cases we study

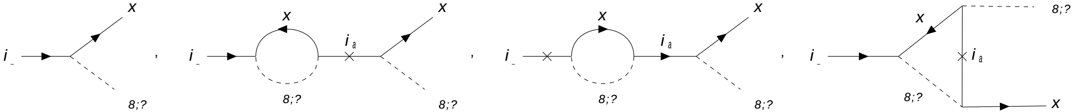
CASE 1:reheaton = generaton = i_1

i_2 interferes, need $h_{i_2} <= h_{i_1}$

If $h_8 > h_?$, SM baryogenesis suppresed unless h_{i_1} h_{i_2} (further study ongoing for the resonant baryonesis limit)

If $h_8 < h_{i_1} < h_?$, SM baryogenesis unsuppressed, twin baryogenesis suppressed

If $h_8; h_? < h_{i_1}$, both unsuppressed.



Cases we study

CASE 2: reheaton $\neq$ generaton

The generaton i_1 and the colored scalar need to be heavier than 500GeV, but now i_1 generates eV neutrino, so coupling $´ = \frac{\sqrt{h_\nu h_i}}{®}$ is large enough for early out of equilibrium decay, leaving the reheating process undisturbed.

The reheaton i_2 can be arbitrary mass. For h_i > W0 - , we get h 0 - .

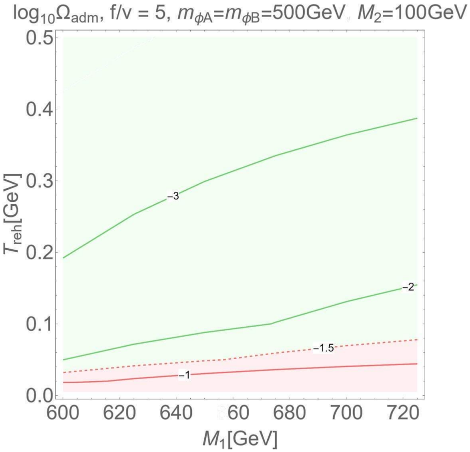
If h_{i_2} 100W0 - , we can now have 0:1.

Further studies in progress for this case.

Preliminary Results

SM baryogenesis fixes coupling combinations.

We can predict the ADM density:



S_X«}0I 8Kg q}0L_H§_nj _j §\0 H9 0 nT }0\09§njQX0j0}9§nj