Vacuum structure of the Z2 symmetric Georgi-Machacek model

ArXiv: 2012.07758

D. Azevedo, P. Ferreira, H. E. Logan, R. Santos

drpazevedo@fc.ul.pt

Ciências ULisboa | CFTC Centro de Física Teórica e Computacional | ISEL | Carleton University

Motivation

The Georgi-Machacek model:
→ SU(2) triplets where ρ=1 at tree-level.
→ Unlike lower multiplets, couplings to the gauge bosons larger than SM.
→ Doubly charged scalars.
Given the complex structure, it allows for several vacua to coexist.

Aim: to catalog all possible vacua and draw conditions for absolute stability.

Z2 symmetric phase

Potential

$$V(\Phi,\Xi) = \frac{\mu_2^2}{2}\mathrm{Tr}(\Phi^\dagger\Phi) + \lambda_1[\mathrm{Tr}(\Phi^\dagger\Phi)]^2 + \frac{\mu_3^2}{2}\mathrm{Tr}(\Xi^\dagger\Xi) + \lambda_2\mathrm{Tr}(\Phi^\dagger\Phi)\mathrm{Tr}(\Xi^\dagger\Xi) + \lambda_3\mathrm{Tr}(\Xi^\dagger\Xi\Xi^\dagger\Xi) + \lambda_4[\mathrm{Tr}(\Xi^\dagger\Xi)]^2 - \lambda_5\mathrm{Tr}(\Phi^\dagger\tau^a\Phi\tau^b)\mathrm{Tr}(\Xi^\dagger t^a\Xi t^b)$$

Two $SU(2)_L \times SU(2)_R$ transformations, first with $\theta_L = \theta_R$ and second $\theta_L = -\theta_R$

$$\Phi_0 = \begin{pmatrix} v_1 & 0 \\ 0 & v_1 \end{pmatrix}, \qquad \Xi_0 = \begin{pmatrix} v_8 - iv_9 & v_6 & 0 \\ -v_{10} + iv_{11} & v_5 & v_{10} + iv_{11} \\ 0 & -v_6 & v_8 + iv_9 \end{pmatrix}. \tag{7}$$

Results

We considered only real vacuum expectation values (VEVs).

- Custodial vacuum.
- Dark vacuum.
- Unphysical vacua:
  - Charge-breaking.
  - Massless Z boson.
  - Null Weinberg angle.

The DM phase is the global minima if:

$$\min\left(\frac{1}{2}\lambda_3 + \lambda_4\,,\ \lambda_3 + \lambda_4\right) \geq \frac{\mu_3^4}{2v^2 m_h^2}$$

Conclusions:

- New DM phase.
- Catalog of all real vacua.
- Necessary conditions for physical global minima.

Aknowledgements

@cftc.fcul @cftc.fcul

DA, PF and RS supported by FCT contacts UIDB/00618/2020,UIDP/00618/2020,PTDC/FIS-PAR/31000/2017,CERN/FIS-PAR/0002/2017,CERN/FIS-PAR/0014/2019, and by the HARMONIA project, contract UMO-2015/18/M/ST2/0518. HEL is supported NSERC. Also supported by H2020-MSCA-RISE-2014 No. 645722 (NonMinimalHiggs).