SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15108
STSM title: Phenomenological study ot the 2HDM gBGL and gFC
STSM start and end date: DD/MM/YYYY to DD/MM/YYYY 02/02/2020 to 15/03/2020
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PURPOSE OF THE STSM:

(max.200 words)
The BGL (Branco, Grimus and Lavoura) 2HDM [1] are Minimal Flavour Violation models which control the FCNC via flavour symmetries. These models have controlled FCNC by CKM matrix parameters in the up or down sector. A generalization of these models (gBGL) [2] that has controlled flavour FCNC in both up and down sectors has been studied.

A general study of the 2HDM that forbid FCNC at tree level has also been implemented. For this, we only ask the Yukawa matrices to be diagonalizable at the same time. Then we study the stability under Renormalization Group Equations (RGE) and arrive to a set of models that preserve the original condition (gFC, from general flavour conserving) [3].

The aim of this STCM is to study the phenomenology of both models, gBGL, and gFC. For this purpose, numerical techniques such as Markov chain driven Monte Carlo calculations will be learnt and developed. The immediate goal is to explore the parameter space of the models incorporating experimental information from the LHC, LEP and low energy experiments, and to study relevant consequences for the discovery of physics beyond the Standard Model. Besides detailed studies of the models, this programme requires understanding and implementing theoretical and experimental information concerning Higgs signals strengths, lepton flavor universality tests, b->s transitions, neutral meson mixings, perturbativity and unitarity of the scalar potential, results from LEP and LHC direct searches, and existing discrepancies in anomalous magnetic moments of both the electron and the muon.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

(max.500 words)

As it was planned, different techniques to study the phenomenology of the gBGL and gFC models have been implemented. The full study of the gFC model has been done, fitting the free parameters of the model with the current data, mainly the Higgs signals strengths, lepton flavor universality, b->s transitions, meson mixing ,perturbativity and unitarity of the scalar potential, LEP and LHC direct searches and electron and muon g-2. For calculating and checking out calculation, the UFO model for Madgraph[5] at NLO has been implemented using Feynrules[6] and NLOCT[7]. One of the nicest features of the gFC 2HDM is that, given that the leptonic Yukawa matrices are diagonal but arbitrary, it is possible to explain both electron and muon g-2 anomalies at

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the same time. This is not very common given that they have opposite sign and this cannot be achieved with lepton couplings proportional to masses.

The bases to study the full phenomenology of the gBGL model have been set. Furthermore, a new project to develop the leptonic sector of the gBGL has started. The idea is to study the connection between spontaneous CP violation and the Scalar Flavor Changing Neutral Currents [4] and the connection between this in the quark and lepton sectors. Both possibilities of having Dirac or Majorana Neutrinos will be studied.

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[4] Nebot, M., Botella, F.J. & Branco, G.C. Vacuum induced CP violation generating a complex CKM matrix with controlled scalar FCNC. Eur. Phys. J. C 79, 711 (2019). https://doi.org/10.1140/epjc/s10052-019-7221-6
[5] Alwall, J., Frederix, R., Frixione, S. et al. The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations. J. High Energ. Phys. 2014, 79 (2014). https://doi.org/10.1007/JHEP07(2014)079
[6] A. Alloul, N. D. Christensen, C. Degrande, C. Duhr, B. Fuks. FeynRules 2.0 — A complete toolbox for tree-level phenomenology. Computer Physics Communications, Volume 185, Issue 8, 2014, 2250-2300, https://doi.org/10.1016/j.cpc.2014.04.012.
[7] C. Degrande. Automatic evaluation of UV and R2 terms for beyond the Standard Model Lagrangians: A proof-of-principle. Computer Physics Communications, 197, 2015, 239-262, https://doi.org/10.1016/j.cpc.2015.08.015.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The main result in the short term is a research paper that will be published soon on the explanation of the electron and muon g-2 anomalies in the gFC 2HDM. As has been explained, a global fit to all the available data has been done giving interesting results. In the medium term, another article about the leptonic sector of the gBGL will be published. This work also opens many future possibilities on these models. On the long term, the basis to study the whole phenomenology of the gBGL has been set. The necessary techniques are now developing. When this is done, we will be in a position to extend the kind of work performed in the gFC case.

FUTURE COLLABORATIONS (if applicable)

As has been explained, the collaboration between Valencia and Lisbon is ongoing. We will keep working on the gBGL models in the short term. In the long term we will keep working together due to our strong links and our similar interests, that is, Flavor physics, 2HDM, CPT violation studies and more.