Exploration of a TeV-Scale Higgs Troika Scenario for Baryon Asymmetry

Hooman Davoudiasl*,[1] Ian M. Lewis†,[2] and Matthew Sullivan‡[2]

[1] *High Energy Theory Group, Physics Department*
Brookhaven National Laboratory, Upton, New York 11973, USA
[2] *Department of Physics and Astronomy, University of Kansas, Lawrence, Kansas, 66045 USA*

(Dated: June 22, 2020)

The origin of the baryon asymmetry of the Universe (BAU) remains a fundamental open question. In Ref. [1] it was proposed that a model with three Higgs doublets, dubbed the *Higgs Troika*, could typically provide the needed ingredients to address this question. Apart from right-handed neutrinos, which provide a compelling explanation of non-zero masses for the observed neutrinos, this scenario only requires the addition of two extra Higgs doublets to the Standard Model (SM).

The decay of the additional Higgs doublets into neutrinos, in the presence of extra sources of CP violation present in the model on general grounds, can provide for a lepton asymmetry that can be converted into the BAU through thermal electroweak processes known as *sphalerons*. This scenario does not require a first order electroweak phase transition.

While a specific pattern of Yukawa couplings was studied in Ref. [1], the Higgs Troika mechanism is quite general and could have many different realizations. Hence, we propose to study the phenomenology of the Higgs Troika scenario beyond the specific model that was considered previously. There are many reasons why this scenario is interesting to study:

1. The new Higgs doublets are required to have a mass at or above the TeV scale. Therefore, these state could be produced at high energy colliders. That is, this setup could be potentially testable if the new states are not far above the weak scale.

2. As stated above, Ref. [1] only studied one Yukawa coupling pattern. For Snowmass, we will consider alternative patterns of couplings for the extra Higgs bosons and their implications for collider physics, within the space of parameters for viable baryogenesis.

3. Ref. [1] only considered Drell-Yan production of the new Higgs doublets. With different Yukawa structures, we will study the feasibility of single production of the new Higgs bosons at colliders via direct coupling between the heavy Higgses and quarks.

4. As shown in Ref. [1], this scenario can also have interesting signatures at low energy, high intensity experiments. We will study the complementarity between the collider and low energy searches for a variety of realizations of this model.

For TeV-scale new states, a wide variety of signals can be within reach of planned and envisioned experiments in the future, where the mechanism for the generation of the BAU could be manifested and directly probed.

[1] H. Davoudiasl, I. M. Lewis and M. Sullivan, Phys. Rev. D **101**, no.5, 055010 (2020) doi:10.1103/PhysRevD.101.055010 [arXiv:1909.02044 [hep-ph]].