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Searching for Extra Higgs Bosons in the General 2HDM

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Since the landmark discovery in 2012 of the h(125) Higgs boson at the LHC, it should be a nobrainer to pursue the existence of a second Higgs doublet. We advocate, however, the general 2HDM (g2HDM) that possesses a second set of Yukawa couplings. The extra top Yukawa coupling ρtt drives electroweak baryogenesis (EWBG), i.e. generating Baryon Asymmetry of the Universe (B.A.U.) with physics at the electroweak scale —hence relevant at the LHC! At the same time, the extra electron Yukawa coupling ρee keeps the balance towards the stringent ACME2018 & JILA2023 bounds on the electron electric dipole moment (eEDM), spectacularly via the fermion mass and mixing hierarchies observed in the Standard Model —Discovery could be imminent (possibly followed by nEDM echo)!
EWBG suggests that exotic Higgs bosons H, A, H^+ in g2HDM ought to be sub-TeV in mass, with effects naturally well-hidden so far by 1) flavor structure, i.e. the aforementioned fermion mass-mixing hierarchies; and 2) the emergent alignment phenomenon (i.e. small h–H mixing) that suppresses processes such as t ⟶ ch, with the equivalent best limit by CMS and ATLAS. It is then natural to pursue direct search modes such as cg ⟶ tH/A ⟶ ttc(bar) with extra top Yukawa couplings ρtc and ρtt that are not alignment-suppressed; the results have just been published by CMS in 3/2024, which was preceded by ATLAS. CMS would now pursue cg ⟶ bH^+ ⟶ btb(bar), as well as continue to study t ⟶ ch and ttc(bar) by adding Run III data, all with discovery potential. CMS also continues to pursue Bs,d ⟶ μμ, where the result published in 2023 has changed the world view.
Belle II would probe g2HDM with precision flavor measurements such as B ⟶ μν, τν; a ratio deviating from 0.0045 would provide a smoking-gun. The τ ⟶ μγ process would need a large dataset.
With H, A, H^+ expected at 300–600 GeV hence ripe for LHC search, we pursue lattice simulation studies of first order electroweak phase transition, a prerequisite for EWBG in the early Universe, the main motivation for our program. We also investigate the Landau pole phenomenon of g2HDM Higgs sector for a new strong interaction scale, which could prove crucial for the future of collider physics.
Thus, our Decadal Mission:
"Find the extra H, A, H^+ bosons; Crack the Flavor code; Solve the Mysterious B.A.U.!"

Mini Symposia (Invited Talks Only)

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