PROCEEDINGS OF SCIENCE

The next Higgs bosons in E_6 inspired supersymmetric models with CP violation

Levent Selbuz*

Department of Engineering Physics, Ankara University,
TR06100, Ankara, Turkey

E-mail: selbuz@eng.ankara.edu.tr

We investigate the effect of CP violation in the Higgs sector of the U(1)′-extended MSSM. We are particularly interested in the mass and decay dependence of the second lightest neutral Higgs boson, in the presence of CP violating phases for μ_{eff}. The masses of the neutral Higgs bosons are calculated at the one-loop level by taking into account the contributions from top and bottom (s)quark sectors. We study the production and decay channels of the second lightest neutral Higgs boson for a set of benchmark points consistent with the current experimental constraints. We then implement the model into standard packages and perform a detailed and systematic analysis of production and decay modes at the HE-LHC with 27 TeV.

40th International Conference on High Energy physics - ICHEP2020
July 28 - August 6, 2020
Prague, Czech Republic (virtual meeting)

*Speaker

PoS(ICHEP2020)309

1. Introduction

The Higgs sector in extended models could provide potential sources of CP violation beyond the phase of the CKM matrix. These phases can affect the masses and couplings of the Higgs bosons to the gauge and matter fields of the model. The phases can also affect production and decay rates patterns. In this work, we analyze the mass spectra of all the Higgs bosons, and the production and decay rates for the second lightest neutral Higgs (H_2^0) in the $U(1)'$-extended MSSM with CP-violating phases at the HE-LHC with 27 TeV.

2. The $U(1)'$ model with CP violation

Gauge extensions of the SM by one or several non-anomalous $U(1)'$ gauge groups can arise naturally from a string-inspired E_6SSM model [1]. Breaking of E_6 yields $SU(3)\times SU(2)\times U(1)_Y \times U(1)'$ as a low energy group. Anomaly-free $U(1)'$ groups are thus generated this way, directly, or as a specific linear combination. They all emerge from breaking of higher groups. In general a $U(1)' \equiv U(1)_{E_6}$ group is defined as $U(1)_{E_6} = \cos\theta_{E_6} U(1)_\chi + \sin\theta_{E_6} U(1)_\psi$, and we distinguish among the different scenario by the values of θ_{E_6} [2].

The superpotential for the effective U(1)$'$ model is [3]

$$W = Y_S \widehat{S}\widehat{H}_u \cdot \widehat{H}_d + Y_t \widehat{U}^c \widehat{Q} \cdot \widehat{H}_u + Y_b \widehat{D}^c \widehat{Q} \cdot \widehat{H}_d, \tag{1}$$

where we considered only the top and bottom Yukawa couplings. As can be seen from (1), in this model the μ term is dynamically induced by the VEV of the S field. We assume some of the soft breaking terms to be complex, selected as the trilinear terms ($A_{t,b,S}$) and the VEV of the Higgs field S. The effective μ parameter is generated by the singlet VEV $\langle S\rangle$, defined as $\mu_{eff} \equiv \mu\, e^{i\theta_S}$, where $\mu = \frac{Y_S v_S}{\sqrt{2}}$. For the remaining parameters we adopt the convention that the parameters are real, and explicitly attach CP violating phases where needed. Explicitly; $\arg(A_S) = \theta_s$, $\arg(S) = \theta_S$, $\arg(A_t) = \theta_t$ and, $\arg(A_b) = \theta_b$.

3. Numerical analysis

We investigate the consequences of each of the anomaly-free groups on H_2^0 production and decay. For this, we introduce benchmark scenarios for each E_6SSM motivated $U(1)'$ model. The constraints on the choice of benchmark values agree with the known astrophysical and collider bounds. To make precise predictions for masses and mixings we include loop corrections. In our model, $M_{H_2^0}$ shows explicit dependence on the CP violating phases θ_S and θ_t. We present our results for the dependence of the masses on the CP violating phases θ_S and θ_t, as well as with $\tan\beta$ in Fig. 1. To analyze the decay width of H_2^0, we first calculate its total production cross section in various models at 27 TeV HE-LHC. The total production cross sections are roughly $\sigma(\mathrm{pp} \to \mathrm{H_2^0 Z}) \sim 10^{-2}$ fb, $\sigma(\mathrm{pp} \to \mathrm{H_2^0 W^\pm}) \sim 10^{-3}$ fb, $\sigma(\mathrm{pp} \to \mathrm{H_2^0 H_1^0}) = [1.4 - 27.4]$ fb and $\sigma(\mathrm{pp} \to \mathrm{H_2^0 H^+}) = [0.25 - 1.63]$ fb for $M_{H_2^0} = [0.6 - 1]$ TeV . In Fig. 2 we plot the variation of the branching ratios of H_2^0 with $\tan\beta$ and the CP violating phase θ_S.

Our analysis has two main goals: (a) analyze effects of CP violation on the second lightest Higgs masses and decays, and (b) look for differences among each of the $U(1)'$ models for decay patterns, and identify characteristic signatures.

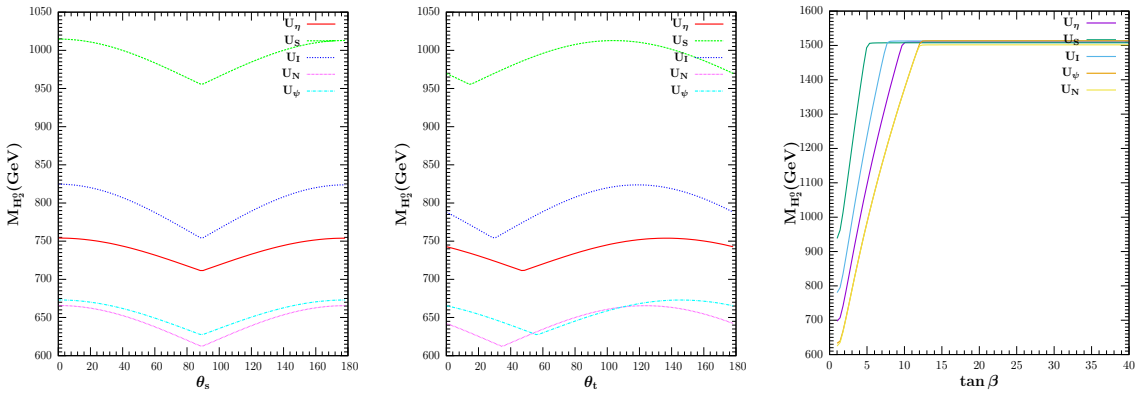

Figure 1: Mass of the second lightest neutral Higgs boson as a function of θ_S, θ_t, and $\tan\beta$ for $U(1)_\eta$, $U(1)_S$, $U(1)_I$, $U(1)_N$ and $U(1)_\psi$ models.

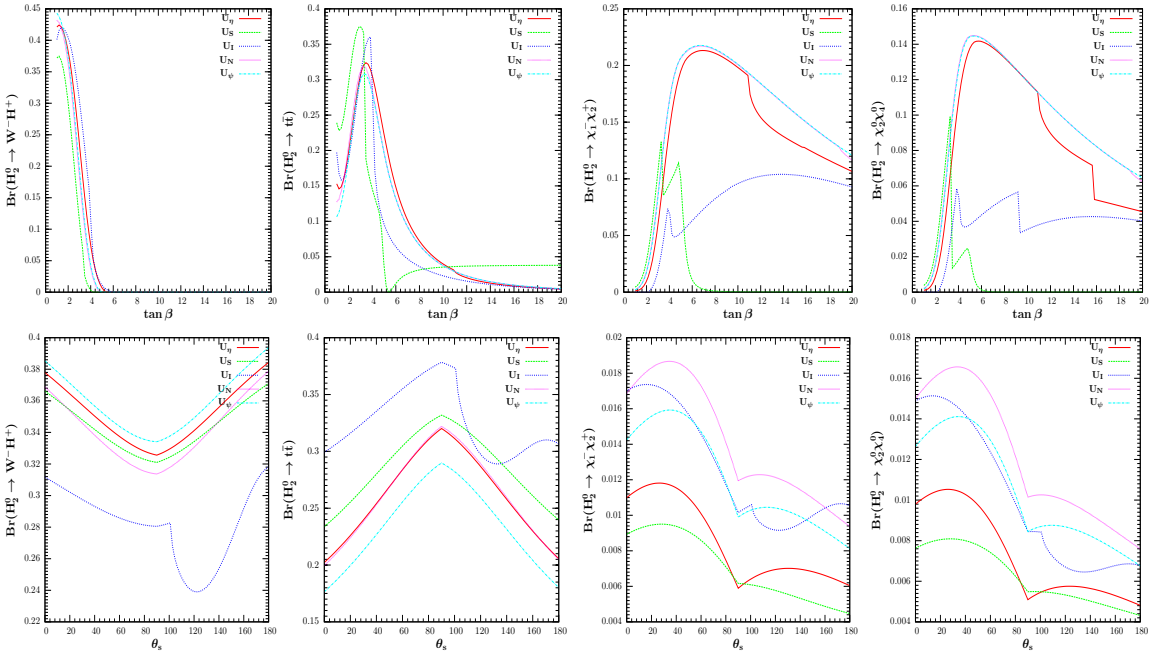

Figure 2: Branching ratios of H_2^0 as a function of $\tan\beta$ and θ_S for $U(1)_\eta$, $U(1)_S$, $U(1)_I$, $U(1)_N$ and $U(1)_\psi$ models.

References

[1] S. M. Barr, *Effects of Extra Light Z Bosons in Unified and Superstring Models*, *Phys. Rev. Lett.* **55** 2778 (1985).

[2] P. Langacker, *The Physics of Heavy Z′ Gauge Bosons*, *Rev. Mod. Phys.* **81** 1199 (2009) [hep-ph/0801.1345].

[3] Frank, L. Selbuz, L. Solmaz and I. Turan, *Higgs bosons in supersymmetric U(1) models with CP violation*, *Phys. Rev. D* **87** no.7 075007 (2013) [hep-ph/1302.3427].