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Higgs Alignment and Leptonic Signatures in a 3HDM+\(U(1)_R\)

We study the Higgs phenomenology of an anomaly-free three-Higgs-doublet model with an additional chiral $U(1)_R$ symmetry. In this framework, different charged leptons couple to different scalar doublets, leading to characteristic deviations in the Higgs couplings while allowing suppressed Dirac neutrino masses through the extended scalar sector.

We focus on the phenomenology of the 125 GeV Higgs boson along the $v_1 = v_2 \equiv v_{12}$ direction, which suppresses the tree-level $Z - Z'$ mixing contribution. The scalar mixing is parametrized through
\begin{equation}
s_1=\sin(\alpha_1-\beta_1), \qquad
s_2=\sin(\alpha_2-\beta_2),
\end{equation}
which determine the deviations of the leptonic and vector-boson Higgs couplings from their Standard Model values.

We perform numerical scans over the scalar mixing parameters and v_{12}, followed by a statistical analysis using Higgs signal-strength constraints implemented with HiggsSignals. We first impose SM-like requirements on the vector and third-generation Higgs couplings and subsequently investigate the allowed regions of the leptonic coupling modifiers κ_e^2 and κ_μ^2. One- and two-dimensional $\Delta\chi^2$ profiles are constructed to quantify the preferred regions and correlations among the model parameters and Higgs couplings.

The analysis shows that Higgs data strongly constrain the scalar alignment directions, while allowing non-trivial deviations in the electron and muon couplings. In the range $10 \leq v_{12} \leq 20$ GeV, the fit exhibits only a mild dependence on v_{12}, with a tendency toward larger values. The resulting constraints provide a quantitative characterization of the leptonic Higgs-coupling deviations in this 3HDM + $U(1)_R$ framework.

These results illustrate how precision Higgs measurements can probe the scalar sector responsible for the fermion mass structure and provide complementary constraints on models with suppressed $Z - Z'$ mixing and Dirac neutrino masses.

Academic position of the presenting author

Ph.D. Student

Primary authors: AGUDELO JARAMILLO, Kimy (Universidad Catolica del Norte); Dr BONILLA, Cesar (Universidad Católica del Norte)

Presenter: AGUDELO JARAMILLO, Kimy (Universidad Catolica del Norte)

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