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Imprint of quark flavor violating SUSY in h(125) decay width ratios at future lepton colliders

We study the CP-even neutral Higgs boson decays $h \to c\bar{c}, b\bar{b}, \gamma\gamma, gg$ in the Minimal Supersymmetric Standard Model (MSSM) with general quark flavor violation (QFV), identifying the h as the Higgs boson with a mass of 125 GeV. We compute the width ratios of these h decays focusing on their deviations from the standard model (SM) predictions. We perform a systematic MSSM parameter scan including Supersymmetric (SUSY) QFV parameters in this study, respecting all the relevant constraints, i.e. theoretical constraints from vacuum stability conditions and experimental constraints, such as those from K- and B-meson data, electroweak precision data, the 125 GeV Higgs boson data, as well as the limits on SUSY particle masses from the LHC experiments. We also take into account the expected SUSY particle mass limits from the future HL-LHC experiment in our analysis. We find that the experimental measurement errors as well as the MSSM prediction uncertainties tend to cancel out significantly in the width ratios, making the measurement of these width ratios a very sensitive probe of virtual SUSY loop effects in these h decays at future lepton colliders such as ILC, CLIC, CEPC, FCC-ee and muon-collider (MuC). We also find that the deviations of the width ratios can be significantly enhanced compared with that of a single width; e.g. the deviation of the ratio of the widths of the h decays to $b\bar{b}$ and $c\bar{c}$ from the SM value can exceed +100% and that to $\gamma\gamma$ and gg can be as large as about +8%. We also find significant correlations between the deviation in the single width and that in the width ratio; e.g. we find a very strong correlation between the deviation of the width of the h decay to $c\bar{c}$ from the SM and that of the ratio of the widths of the h decays to $b\bar{b}$ and $c\bar{c}$ from the SM. In strong contrast to the usual studies in the MSSM with quark flavor conservation, we find that the deviations of these MSSM decay width ratios from their SM values can be quite sizable due to (i) large scharm-stop mixing and large scharm/stop involved trilinear couplings $T_{U23}, T_{U32}, T_{U33}$, (ii) large sstrange-sbottom mixing and large sstrange/sbottom involved trilinear couplings $T_{D23}, T_{D32}, T_{D33}$ and (iii) large bottom Yukawa coupling Y_b for large $\tan\beta$ and large top Yukawa coupling Y_t. Future lepton colliders such as ILC, CLIC, CEPC, FCC-ee and MuC can observe such sizable deviations of the width ratios from the SM at high signal significance ***even after*** the failure of SUSY particle discovery at the HL-LHC. In case the deviation pattern shown here is really observed at the lepton colliders, then it would strongly suggest the discovery of QFV SUSY (the MSSM with general QFV).
This work is based on the following papers and contains substantial new findings:
Phys. Rev. D 91 (2015) 015007 [arXiv:1411.2840 [hep-ph]]
JHEP 1606 (2016) 143 [arXiv:1604.02366 [hep-ph]]
IJMP A34 (2019) 1950120 [arXiv:1812.08010 [hep-ph]]
PoS(EPS-HEP2021) 594, 2021 [arXiv:2111.02713 [hep-ph]]
ILC White Paper for Snowmass 2021 [arXiv:2203.07622]
PoS(ICHEP2022) 536, 2022 [arXiv:2211.07243 [hep-ph]].

Collaboration / Activity

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