$h^0 \to c\bar{c}$ as a test case for quark flavor violation in the MSSM†

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It is very important to determine if the SM (Standard Model)-like Higgs boson discovered at the LHC (Large Hadron Collider) in 2012[1,2] is the SM Higgs boson or the Higgs boson of New Physics. This is the most important issue in the present particle physics world. In this report based on our paper[3], we study the possibility that it is the lightest Higgs boson h^0 of the Minimal Supersymmetric Standard Model (MSSM), by focusing on the width of the decay $h^0 \to c\bar{c}$. We compute the decay width at a full one-loop level in the $\overline{DR}$ renormalization scheme in the MSSM with nonminimal Quark Flavor Violation (QFV).

We take our reference QFV scenario as shown in Table 1 in Ref.[3]. The main features of the scenario are: (i) it contains large $\tilde{c} - \tilde{t}$ (scharm-stop) mixings and large QFV trilinear couplings of squark-squark Higgs boson, and (ii) it satisfies the strong constraints on QFV from the B meson data, where scharm [stop] is the supersymmetry (SUSY) partner of the charm [top] quark. In this scenario, the lightest up-type squarks $\tilde{u}_1$ and $\tilde{u}_2$ are strong mixtures of $\tilde{c}_{L/R}$ - $\tilde{t}_{L/R}$, and the trilinear couplings ($\tilde{c}_L$ - $\tilde{t}_R$ - h^0, $\tilde{c}_R$ - $\tilde{t}_L$ - h^0, $\tilde{t}_L$ - $\tilde{t}_R$ - h^0 couplings) are large; therefore, $\tilde{u}_{1,2} - \tilde{u}_{1,2} - h^0$ couplings are large. This leads to an enhancement of the $\tilde{u}_{1,2}$ - $\tilde{u}_{1,2}$ - $\tilde{g}$ -loop vertex correction to the decay amplitude of $h^0 \to c\bar{c}$ shown in Fig. 1, where $\tilde{g}$ is a gluino, which is a hypothetical supersymmetric partner of a gluon. Thus, this results in a large deviation of the MSSM prediction for the decay width $\Gamma(h^0 \to c\bar{c})$ from the SM prediction.

In Fig. 2, we show the contour plot of the deviation of the MSSM prediction from the SM prediction $\Gamma^{SM}(h^0 \to c\bar{c})$ = 0.118 MeV in the δ_{23}^{uRR} - δ_{23}^{uLR} plane, where δ_{23}^{uRR} and δ_{23}^{uLR} are the $\tilde{c}_R$ - $\tilde{t}_R$ and $\tilde{c}_L$ - $\tilde{t}_R$ mixing parameters, respectively. We see that the MSSM prediction is very sensitive to the QFV parameters δ_{23}^{uRR} and δ_{23}^{uLR}, and that the deviation of the MSSM prediction from the SM prediction can be very large (as large as ~ 35%). We have found that the MSSM prediction becomes nearly equal to the SM prediction if we switch off all the QFV parameters in our reference QFV scenario.

The observation of any significant deviation of the decay width from its SM prediction indicates new physics beyond the SM. It is important to estimate the theoretical and experimental uncertainties of the width reliably in order to confirm such a deviation. The relative error of the SM width is estimated to be ~ 6%[4]. The relative error of the MSSM width is estimated to be ~ 6%[3]. As seen in Fig. 2, the deviation of the MSSM width from the SM width can be as large as ~ 35%. Such a large deviation can be observed at a future e^+e^- collider ILC (International Linear Collider) with a CM energy 500 GeV and an integrated luminosity of 1600 fb^{-1}, where the expected experimental error of the width is ~ 3%[5]. A measurement of the width at LHC is a hard task because of the difficulties in charm-tagging.

In this report, we have shown that the full one-loop corrected decay width $\Gamma(h^0 \to c\bar{c})$ is very sensitive to the QFV parameters in the MSSM. In a scenario with large $\tilde{c} - \tilde{t}$ mixings, the width can differ up to ~ 35% from its SM value. After estimating the uncertainties of the width, we conclude that an observation of these MSSM QFV effects is possible at ILC. Therefore, we have a good opportunity to discover the QFV SUSY effect in this decay $h^0 \to c\bar{c}$ at ILC.

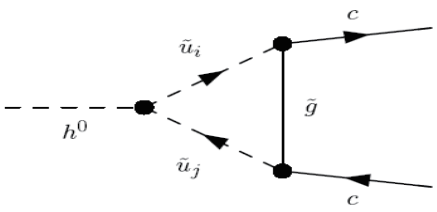

Fig. 1. Gluino-loop vertex correction to $h^0 \to c\bar{c}$.

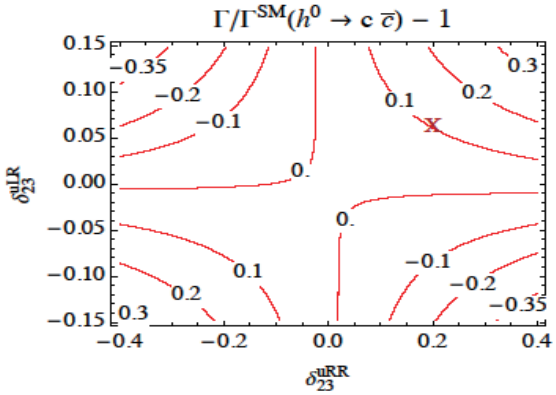

Fig. 2. Contour plot of the deviation of the full one-loop level MSSM width $\Gamma(h^0 \to c\bar{c})$ from the SM width $\Gamma^{SM}(h^0 \to c\bar{c})$ for our reference QFV scenario.

References

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