Contribution ID: **71** Type: **not specified**

Exclusive Radiative Higgs Decays as Probes of Non-Standard Yukawa Couplings

Thursday, 27 August 2015 15:30 (30 minutes)

We present a detailed analysis of the rare exclusive Higgs-boson decays into a single vector meson and a photon and investigate the possibility of using these processes to probe the light-quark Yukawa couplings. We work with an effective Lagrangian with modified Higgs couplings to account for possible new-physics effects in a model-independent way. The $h \to V\gamma$ decay rate is governed by the destructive interference of two amplitudes, one of which involves the Higgs coupling to the quark anti-quark pair inside the vector meson. We derive this amplitude at next-to-leading order in α_s using QCD factorization, including the resummation of large logarithmic corrections and accounting for the effects of flavor mixing. The high factorization scale $\mu \sim m_h$ ensures that our results are rather insensitive to poorly known hadronic parameters. The second amplitude arises from the loop-induced effective $h\gamma\gamma^*$ and $h\gamma Z^*$ couplings, where the off-shell gauge boson converts into the vector meson. We devise a strategy to eliminate theoretical uncertainties related to this amplitude to almost arbitrary precision. This opens up the possibility to probe for $calO(1)$ modifications of the c- and b-quark Yukawa couplings and $calO(30)$ modifications of the s-quark Yukawa coupling in the high-luminosity LHC run. In particular, we show that measurements of the ratios $\mathrm{Br}(h \to \Upsilon(nS)\,\gamma)/\mathrm{Br}(h \to \gamma\gamma)$ and $\mathrm{Br}(h \to b\bar{b})/\mathrm{Br}(h \to \gamma\gamma)$ can provide complementary information on the real and imaginary parts of the b-quark Yukawa coupling. More accurate measurements would be possible at a future 100\,TeV proton-proton collider.

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Session Classification: Higgs Expt., Theory and Phenomenology

Track Classification: Higgs Theory and Experiment