Contribution ID: **1** Type: **not specified**

Improved constraint on Higgs boson self-couplings with quartic and cubic power dependence in the cross section

Precise information on the Higgs boson self-couplings provides the foundation for unveiling the electroweak symmetry breaking mechanism.
Due to the scarcity of Higgs boson pair events at the LHC, only loose limits have been obtained.
This is based on the assumption that the cross section is a quadratic function of the trilinear Higgs self-coupling in the κ framework.
However, if higher-order corrections of virtual Higgs bosons are included,
the function form would dramatically change.
In particular, new quartic and cubic power dependence on the trilinear Higgs self-coupling would appear.
To get this new function form, we have
performed a specialized renormalization procedure suitable for tracking all the Higgs self-couplings in each calculation step.
Moreover, we introduce renormalization of the scaling parameter in the κ framework to ensure the cancellation of all ultraviolet divergences.
With the new function forms of the cross sections in both the gluon-gluon fusion and vector boson fusion channels,
the upper limit of $\kappa_{\lambda_3} = \lambda_{3\mathrm{H}}/\lambda_{3\mathrm{H}}^{\mathrm{SM}}$ by the ATLAS (CMS) collaboration is reduced from 6.6 (6.49) to 5.4 (5.37).
However, it is still hard to extract a meaningful constraint on the quartic Higgs self-coupling $\lambda_{4\mathrm{H}}$ from Higgs boson pair production data.
We also present the invariant mass distributions of the Higgs boson pair at different values of κ_λ, which could help to set optimal cuts in the experimental analysis.

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