

Analytic third-order QCD corrections to top-quark and semileptonic $b \rightarrow u$ decays

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We present the first analytic results of N³LO QCD corrections to the top-quark decay width. We focus on the dominant leading color contribution, which includes light-quark loops. At NNLO, this dominant contribution accounts for 95% of the total correction. By utilizing the optical theorem, the N³LO corrections are related to the imaginary parts of the four-loop self-energy Feynman diagrams, which are calculated with differential equations. The results are expressed in terms of harmonic polylogarithms, enabling fast and accurate evaluation. The third-order QCD corrections decrease the LO decay width by 0.667%, and the scale uncertainty is reduced by half compared to the NNLO result. The most precise prediction for the top-quark width is now 1.321 GeV for $m_t = 172.69$ GeV. Additionally, we obtain the third-order QCD corrections to the dilepton invariant mass spectrum and decay width in the semileptonic $b \rightarrow u$ transition. The perturbative series in the on-shell mass scheme exhibits poor convergence behavior. In the \overline{MS} mass scheme, the scale dependence is greatly improved. A more precise determination of the CKM matrix element V_{ub} could be obtained with such higher-order corrections.

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