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Radiative Corrections to $D_s \to \ell\nu$ and CKM Unitarity Test

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Recently, a violation of the CKM unitarity condition has been reported in the latest charm-meson data and the latest lattice results, once the universal electroweak correction is taken into account. In this talk, we analytically derive for the first time the complete one-loop electroweak (EW) and QED corrections to the $D_s^+ \to \ell^+\nu_\ell$ decays for $\ell = \mu, \tau$. Our analysis incorporates both short-distance EW-QED corrections, which are beyond the leading-logarithmic approximation (the so-called Sirlin factor), and long distance soft photon corrections depending on the maximum total energy of undetected photons with their resummation. Although the inclusive photon QED corrections to the meson leptonic decays are well known, they do not match the actual measurement circumstances in $D_s^+ \to \mu^+\nu_\mu$. We find $|V_{cs}|_{D_s} = 0.991 \pm 0.007$ from the latest data on D_s^+ leptonic decays. We show that properly including these radiative corrections is essential to bring the second-column CKM unitarity tests into agreement with the Standard Model expectation. The study emphasizes that the current limiting factor in confirming CKM unitarity is the precision of QED corrections, and it points out that improving lattice simulations, taking the QED corrections into account, would be desirable for a more robust confirmation.

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