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# First priciples lattice QCD calculation of inclusive semileptonic decays of the Ds meson

Inclusive processes pose a long-standing challenge for lattice QCD due to their inherently multi-hadron nature and the need to access fully summed final states. Here, we demonstrate how first-principles methods can now overcome these obstacles through spectral reconstruction techniques. We present a first-principles lattice QCD study of the inclusive semileptonic decays of the $D_s$ meson, providing precise determinations of the decay rate and the first two lepton-energy moments with full control over systematic uncertainties. Our predictions show excellent agreement with experiment and demonstrate that, while inclusive $D_s$ decays are not yet as competitive as exclusive modes for extracting $|V_{cs}|$, they hold strong potential to become a precision tool in the near future. Using the same lattice methods, we also investigate the inclusive process $\tau \to X_{us}\nu_\tau$, achieving subpercent accuracy and motivating future first-principles calculations of long-distance isospin-breaking effects. These studies establish inclusive decays as a new precision frontier in lattice QCD, enabling increasingly accurate determinations of CKM parameters and providing stringent tests of the Standard Model.

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