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The photon energy spectrum in B$\to X_s\gamma$ at N^{3}LL'

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SCET lies at the foundation of our understanding of inclusive B meson decays. It allows us to factorize the spectrum into hard, jet, and hadronic soft functions. The hadronic soft function can be further factorized into perturbative partonic soft function and nonperturbative shape function. The shape function is a necessary ingredient for extraction of $|V_{ub}|$ CKM matrix element from $B \to X_u l\nu$ spectrum, and it can be extracted from inclusive measurements of $B \to X_s\gamma$ spectrum.

I will present our preliminary predictions of $B \to X_s\gamma$ spectrum at $\mathrm{N^3LL'}$+$\mathrm{N^3LO}$, which we implemented in the SCETlib library. Although only the soft and jet functions are fully known at $\mathrm{N^3LO}$, we parameterize the unknown 3-loop hard function coefficient and nonsingular contributions in terms of nuisance parameters. The variation of these nuisance parameters provides a robust estimate of the uncertainty that arises from our ignorance of these 3-loop terms.

In order to arrive at stable predictions it is essential to use a short-distance scheme for the b-quark mass. It is well-known that the pole mass scheme suffers from a renormalon problem, which leads to very poor convergence. We demonstrate that predictions in 1S mass scheme, which has been used for this process in the past, start to break down at $\mathrm{N^3LL'}$ due to a mismatch between the 1S scale and the soft scale of this process. I will show that the MSR mass scheme yields much more stable results.

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