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TMD wave functions and soft functions at one-loop in LaMET

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TMDPDFs and TMDWFs are important physical quantities characterizing the distributions of constituent momentum in the hadron, and reflect the non-perturbative internal structure of hadrons. In large-momentum effective theory (LaMET), the TMDWFs can be extracted from the first-principle simulation of a four-quark form factor and quasi-distributions. We provide a one-loop proof of TMD factorization of the form factor by using expansion by regions. For the one-loop validation, we also present a detailed calculation of $O(\alpha_s)$ perturbative corrections to these quantities, in which we adopt a modern technique for the calculation of the TMD form factor based on the integration by part and differential equation. The one-loop hard functions are then extracted. Using lattice data from Lattice Parton Collaboration on quasi-TMDWFs, we estimate the effects from the one-loop matching kernel and find that the perturbative corrections depend on the operator to define the form factor, but are less sensitive to the transverse separation. These results will be helpful to precisely extract the soft functions and TMD wave functions from the first principle in the future.

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