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TMD Factorization and Renormalization at Next-to-Leading Power

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Since shortly after the discovery of partons, people have thought about probing their transverse momentum inside hadrons. For example, in 1978 it was shown to give rise to an azimuthal cos(phi) asymmetry of the outgoing hadrons in the process of semi-inclusive DIS (SIDIS), known as the Cahn effect. The cos(phi) distribution, as well as a number of other asymmetries in both SIDIS and Drell-Yan, are difficult to study since in QCD they first appear at subleading order in the small transverse momentum expansion. These observables have traditionally been studied at tree level using the parton model. In this talk I show that the use of effective field theory makes it possible to treat these observables systematically. Utilizing the soft-collinear effective theory formalism we completely determine the structure of contributions to all orders in perturbation theory. Interestingly, we find that dynamical soft gluon contributions remains simple at this power. We show that the only new ingredients are a set of the quark-gluon-quark (qgq) correlators, which come along with only one new Wilson coefficient. Perturbative matching calculations for the qgq correlators reveal novel additive rapidity divergences as well as endpoint divergences in the convolution of energy fractions, thus making the renormalization and factorization nontrivial and interesting. I discuss our solution to removing these divergences to define renormalized qgq correlators. Our results for the subleading power azimuthal asymmetries, establish them as useful observables within QCD, and enable higher precision predictions.

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