Large order behaviour and renormalons

SCET matching coefficient of $q\bar{q}$ production current, SCET Jet function and bHQET Jet function in the large N_f limit

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Abstract

The use of effective field theories (EFTS) allows to look at full theory observables from a top down perspective and to derive all order factorization theorems. In particular, previous work has shown that Soft Collinear Effective Theory (SCET) factorizes the massless $q\bar{q}$ production cross-section, and SCET with boosted Heavy Quark Effective Theory (bHQET) factorizes the massive $t\bar{t}$ production cross-section. The pieces involved in this factorization are the hard, jet and soft functions. In this work we focus on the hard and jet functions, and we compute the latter in its SCET and bHQET versions. We present their leading order contributions in the so called large N_f expansion, whose expansion parameter is $\alpha_S^n N_f^{n-1}$. The approach we take is mainly based on Feynman diagrams, and hence it is conceptually not complicated, yet it leads to strong results. We give not only the expressions at $\mathrm{N_f LO}$, but also we extract its renormalization constants and anomalous dimension, for arbitrary n. For small n ($n = 1, 2, 3$) our results are in perfect agreement with known results, while for higher n we give the exact contribution of the larger power of N_f.

The large N_f expansion is also appropriate to study the large order behavior, characterized as poles on the real axis of the Borel plane. We compute the resummed Borel expression for the hard and jet functions, extract their renormalons and give the ambiguity associated to the IR renormalon closest to the origin.