Sudakov Suppression of Collins Effect Asymmetries

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Since no experimental data on h_1 (transversity) exists, the following question naturally arises: what are the realistic scenarios to obtain such data? The so-called Collins effect in principle offers one such possibility, but the analysis of Collins effect asymmetries must be preformed beyond tree level and this turns out to be quite involved.

The single transverse spin asymmetry in semi-inclusive deep inelastic scattering, originally proposed by Collins [1], is expressed in terms of the transversity function h_1 and the so-called Collins fragmentation function $H_1^\perp$ (both undetermined still). This asymmetry expression is not based on a *collinear* factorization theorem, but rather it factorizes in a way as described in Ref. [2]. Hence, the analysis beyond tree level becomes quite involved. Soft gluon radiation corrections do not cancel, but exponentiate into so-called Sudakov factors, suppressing the asymmetry considerably as the energy (Q^2) increases. This Sudakov suppression (the lowering and broadening of the transverse momentum distribution) occurs in addition to the downward evolution of the transversity and Collins functions themselves (both vanish asymptotically). This means that tree level studies of such asymmetries tend to overestimate the magnitude [3].

However, if one projects out the asymmetry from the cross section, one can obtain an observable that is not sensitive to Sudakov factors and its leading order (LO) Q^2 dependence is solely governed by the LO evolution equations of the transversity function and a particular transverse momentum moment of the Collins function $H_1^{\perp(1)}$ (the evolution of the latter is known in the large N_c limit [4]).

Similar conclusions hold for another Collins effect driven asymmetry, namely a $\cos(2\phi)$ asymmetry in electron-positron annihilation into two almost back-to-back pions [5], which allows for an independent determination of the Collins function. Beyond tree level this asymmetry effectively receives a Sudakov *power* suppression with rising energy [3].

On the other hand, the single spin asymmetries arising from the interference fragmentation functions $\delta\hat{q}_I^a(z)$ [6] are based on a collinear factorization theorem and therefore, perturbative QCD corrections are more easily included, no Sudakov factors appear. We note that the evolution equation for $\delta\hat{q}_I(z)$ is identical to that of the transversity *fragmentation* function. NLO corrections can be calculated in the same way as done for A_{TT}^{DY}. Furthermore, one can obtain the interference fragmentation functions from electron-positron annihilation into back-to-back pion pairs [7]. Combining such a result with the single spin asymmetry in for instance $p\,p^\uparrow \to \pi^+\pi^- X$ (to be measured at RHIC), seems –at present– to be one of the most realistic ways of obtaining information on the transversity function.

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