Single transverse-spin asymmetry in $p^\uparrow p \to \pi X$ and $ep^\uparrow \to \pi X$

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Our interest in the single transverse spin asymmetry for the pion production in pp and ep collisions resides in the fact that it probes particular quark-gluon correlation in the hadrons (higher twist effect) which is not included in the twist-2 parton distributions. QCD analysis for the asymmetry is crucial for the ongoing RHIC-SPIN, HERMES and COMPASS experiments.
In this contribution, we will present an analysis for the asymmetry in the framework of the collinear factorization [1-2]. According to the generalized QCD factorization theorem, the polarized cross section for $p^\uparrow p \to \pi X$ consists of three kinds of twist-3 cross sections,

$$\text{(A)} \qquad G_a(x_1,x_2) \otimes q_b(x') \otimes \widehat{q}_{c\to\pi}(z) \otimes \hat{\sigma}^1_{ab\to c}, \tag{1}$$

$$\text{(B)} \qquad \delta q_a(x) \otimes E_b(x'_1,x'_2) \otimes \widehat{q}_{c\to\pi}(z) \otimes \hat{\sigma}^2_{ab\to c}, \tag{2}$$

$$\text{(C)} \qquad \delta q_a(x) \otimes q_b(x') \otimes \widehat{E}_{c\to\pi}(z_1,z_2) \otimes \hat{\sigma}^3_{ab\to c}, \tag{3}$$

and the one for $ep^\uparrow \to \pi X$ likewise receives two contributions,

$$\text{(A}') \qquad G_a(x_1,x_2) \otimes \widehat{q}_{a\to\pi}(z) \otimes \hat{\sigma}, \tag{4}$$

$$\text{(C}') \qquad \delta q_a(x) \otimes \widehat{E}_{a\to\pi}(z_1,z_2) \otimes \hat{\sigma}'. \tag{5}$$

Here the functions with two variables (momentum fractions) $G_a(x_1,x_2)$, $E_a(x_1,x_2)$, $\widehat{E}_{c\to\pi}(z_1,z_2)$ are twist-3 quantities: G_a and E_a are, respectively, the transversely polarized distribution and the unpolarized distribution functions in the nucleon. $\widehat{E}_{c\to\pi}$ is the unpolarized fragmentation function for the pion. a, b and c stand for the parton's species. Other functions are twist-2; $q_b(x)$ the unpolarized distribution, $\delta q_a(x)$ the transversity distribution, $\widehat{q}_{c\to\pi}$ the unpolarized fragmentation function. $\hat{\sigma}^1_{ab\to c}$ *etc* represents the partonic cross section which yields large transverse momentum of the pion.
The analyses of (A) and (B) contributions have been provided in [1] and [2], respectively. Here we extend the analysis to the (C) term (for a preliminary study, see [3]) and the $ep^\uparrow$ case so that we can have more thorough understanding on the hadron structure and the reaction mechanism.

References

[1] J. Qiu and G. Sterman, Phys. Rev. **D59** (1999) 014004.
[2] Y. Kanazawa and Y. Koike, Phys. Lett. **B478** (2000) 121; **B490** (2000) 99.
[3] Y. Koike, hep-ph/0106260, Proceedings of DIS2001. (Bologna, Italy, April, 2001.)