FORWARD DI-JET PRODUCTION IN DILUTE-DENSE COLLISIONS

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I. CONNECTION OF CGC AND HEF

WE DIRECTLY SHOW THAT:

THE HIGH ENERGY FACTORIZATION FORMULA

\[ \frac{d^2 \sigma_{\text{dijets}+}}{d^2 p_T} = \frac{1}{\bar{u}^2 s} \sum_{i,j} \hat{f}_i(x_i, \mu_F) \hat{f}_j(x_j, \mu_F) \sum_{k} K_{xk}^{(i)}(s_{ik}) K_{yj}^{(j)}(s_{jk}) \]

IS EQUIVALENT TO

THE COLOR GLASS CONDENSATE THEORY IN THE DILUTE TARGET LIMIT \( Q_s \ll k_t \sim P_t \):

\[ \frac{d^2 \sigma_{\text{dijets}+}}{d^2 p_T} = \frac{1}{\bar{u}^2 s} \sum_{i,j} \hat{f}_i(x_i, \mu_F) \hat{f}_j(x_j, \mu_F) \sum_{k} K_{xk}^{(i)}(s_{ik}) K_{yj}^{(j)}(s_{jk}) \]

II. IMPROVED TMD FACTORIZATION

WE DERIVE AN IMPROVED TRANSVERSE MOMENTUM DEPENDENT FACTORIZATION FORMULA:

\[ \frac{d^2 \sigma_{\text{dijets}+}}{d^2 p_T} = \frac{1}{\bar{u}^2 s} \sum_{i,j} \hat{f}_i(x_i, \mu_F) \hat{f}_j(x_j, \mu_F) \sum_{k} K_{xk}^{(i)}(s_{ik}) K_{yj}^{(j)}(s_{jk}) \frac{1}{c_{\text{cd}}} \]

IMPROVEMENTS:

INCLUDES ALL FINITE-\( N_c \) CORRECTIONS;
THREE NEW GLUON DISTRIBUTIONS;
ONLY TWO INDEPENDENT GLUON DISTRIBUTIONS PER CHANNEL.

III. UNIFYING FORMULA

WE DERIVE A UNIFYING TRANSVERSE MOMENTUM DEPENDENT FACTORIZATION FORMULA

THE NEW FORMULA IS VALID FOR ARBITRARY VALUE OF THE MOMENTUM IMBALANCE OF THE JETS, \( k_t \)

\[ \frac{d^2 \sigma_{\text{dijets}+}}{d^2 p_T} = \frac{1}{\bar{u}^2 s} \sum_{i,j} \hat{f}_i(x_i, \mu_F) \hat{f}_j(x_j, \mu_F) \sum_{k} K_{xk}^{(i)}(s_{ik}) K_{yj}^{(j)}(s_{jk}) \frac{1}{c_{\text{cd}}} \]

IMPROVEMENTS:

THE MATRIX ELEMENTS ARE OFF-SHELL:

We derive \( k_t \)-dependent matrix elements for TMD factorization with two independent methods:
Standard Feynman diagrams technique;
Helicity method for color-ordered amplitudes.

The matrix elements in the new formula are:

\[ \hat{f}_i(x_i, \mu_F) \hat{f}_j(x_j, \mu_F) \]

IV. PHENOMENOLOGY

WE CALCULATE THE TMD GLUON DISTRIBUTIONS THAT ENTER IN THE UNIFYING FORMULA WITH Kutak-Sapeta non-linear evolution: AND Golec-Biernat-Wusthoff model:

AZIMUTHAL CORRELATIONS IN FORWARD DI-JET PRODUCTION WITH THE UNIFYING FORMULA:

We observe a suppression in the correlation limit and an increase in the decorrelation sector in comparison to HEF:

SUMMARY

- We derive the High-Energy Factorization formula from CGC in the dilute target limit;
- We extend the TMD factorization formula to finite \( N_c \), and we write it with two \( k_t \)-dependent gluon distributions per channel;
- We derive an improved TMD factorization that unifies the different \( k_t \) regimes.

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References