UCLouvain

Collinear Splitting Functions in QCD

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When the M meets the P

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Context

- QCD: interactions of gluons and (massless) quarks

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- QCD: interactions of gluons (spin 1) and quarks (spin 1/2)

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- Amplitudes $\mathcal{A}$: $|\mathcal{A}|^2$ is a probability density

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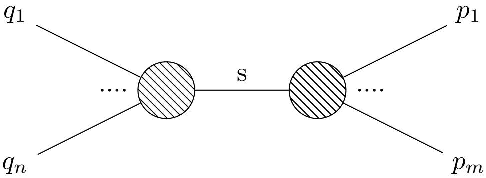
- Amplitudes $\mathcal{A}$: $|\mathcal{A}|^2$ is a probability density
- Collinear limit: $p_i \to p \ \forall i = 1, ..., m$

Factorization and Universality

$$|\mathcal{A}_{a_1,\ldots a_m,\ldots}(p_1,\ldots,p_m,\{q_j\})|^2 \propto \mathcal{T}^{ss'}_{a,\ldots}(p,\{q_j\})P^{ss'}_{a_1,\ldots,a_m}$$

if the particles $a_1,\ldots,a_m$ become collinear.



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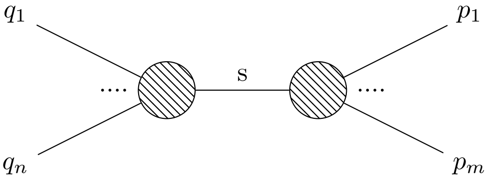
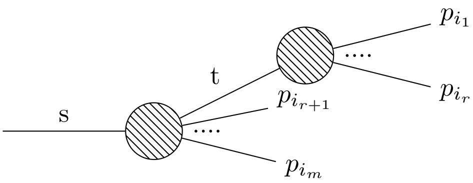


One step further

What about collinear limit of Splitting Functions ?

$$P^{ss'}_{a_1,\ldots,a_m} \propto Q^{ss'tt'}_{a_{i_{r+1}},\ldots,a_{i_m}} P^{tt'}_{a_{i_1},\ldots,a_{i_r}}$$

if the particles $a_{i_1}, \ldots, a_{i_r}$ become collinear.



Remove spin dependence, by averaging:

$$\langle M \rangle = M^{ss'} \frac{d^{ss'}}{n_s}$$

Factorization of squared amplitudes:

$$|\mathcal{A}_{a_1,\dots a_m,\dots}(p_1,\dots,p_m,\{q_j\})|^2 \propto \mathcal{T}^{ss'}_{a,\dots}(p,\{q_j\}) P^{ss'}_{a_1,\dots,a_m}$$

$$\Downarrow$$

$$|\mathcal{A}_{a_1,\dots a_m,\dots}(p_1,\dots,p_m,\{q_j\})|^2 \propto |\mathcal{A}_{a,\dots}(p,\{q_j\})|^2 \langle P_{a_1,\dots,a_m} \rangle$$

Remove spin dependence, by averaging:

$$\langle M \rangle = M^{ss'} \frac{d^{ss'}}{n_s}$$

Factorization of splitting functions (quark case):

$$P^{ss'}_{a_1,\ldots,a_m} \approx Q^{ss'tt'}_{a_{i_{r+1}},\ldots,a_{i_m}} P^{tt'}_{a_{i_1},\ldots,a_{i_r}}$$

$$\Downarrow$$

$$\langle P_{a_1,\ldots,a_m} \rangle \approx \left\langle P_{a_{i_{r+1}},\ldots,a_{i_m}} \right\rangle \left\langle P_{a_{i_1},\ldots,a_{i_r}} \right\rangle$$

Remove spin dependence, by averaging:

$$\langle M \rangle = M^{ss'} \frac{d^{ss'}}{n_s}$$

Factorization of splitting functions (gluon case):

$$P^{ss'}_{a_1,\ldots,a_m} \approx Q^{ss'tt'}_{a_{i_{r+1}},\ldots,a_{i_m}} P^{tt'}_{a_{i_1},\ldots,a_{i_r}}$$

$$\Downarrow$$

$$\langle P_{a_1,\ldots,a_m} \rangle \approx \left\langle P_{a_{i_{r+1}},\ldots,a_{i_m}} \right\rangle \left\langle P_{a_{i_1},\ldots,a_{i_r}} \right\rangle + \text{other terms}$$

Questions ?