Non-global logarithms in hadron collisions at \( N_c = 3 \)

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Recently, there have been a lot of activities in developing Monte Carlo algorithms for simulating parton showers beyond the large-\( N_c \) (leading-\( N_c \)) approximation where \( N_c = 3 \) is the number of colors. Traditionally, in most event generators, the large-\( N_c \) approximation has been the only practical way to keep track of the color indices of many partons involved. Among other observables, the finite-track of the color indices of many partons involved.

In this work, we demonstrate that our approach can be practically applied to hadron collisions where it is probably most useful. We do so by explicitly computing the rapidity gap survival (or ‘veto’) probabilities in Higgs plus dijet production \( pp \to HjjX \). The relevant logarithms are of the form \( (\alpha_s \ln Q/E_{\text{out}})^n \) where \( Q \) is the hard scale (Higgs mass or jet transverse momentum) and \( E_{\text{out}} \ll Q \) is the veto scale.

Consider quark-quark scattering \( q_i(p_1)q_j(p_2) \to q_k(p_3)q_l(p_4)H \) where \( i, j, k, l = 1, 2, 3 \) are color indices. The outgoing quarks with momenta \( p_3, p_4 \) are back-to-back and detected as two jets in the forward and backward directions. We are interested in the probability that the energy emitted in the central rapidity region \( \pi - \theta_{\text{in}} > \theta > \theta_{\text{in}} \) is less than \( E_{\text{out}} \).

The leading-order amplitude can be written as

\[
M_{ijkl} = M_1 \delta_{ik} \delta_{lj} + M_8 t^c_k t^c_l \delta_{ij}.
\]

where \( M_{1,8} \) are amplitudes in the singlet and octet channel. We dress up (1) by attaching soft gluons to external legs in the eikonal approximation. We then square it and average over color indices to get the cross section

\[
M^2_{1,8} P_{qq}^{1,8} + \frac{N_c^2 - 1}{4N_c^2} M^2_8 P_{qq}^8.
\]

\( P_{qq}^{1,8} \) are the gap survival probabilities in the singlet and octet channels.

Fig. 1. Gap survival probability in \( qq \to qqH \), color-octet channel.

\[
P_{qq}^1 = \frac{1}{N_c^2} \left( \text{tr}(U_3 U_1^\dagger) \text{tr}(U_4 U_2^\dagger) \right),
\]

\[
P_{qq}^8 = \frac{\text{tr}(U_3 U_1^\dagger) \text{tr}(U_4 U_2^\dagger) - \text{tr}(U_5 U_3^\dagger) \text{tr}(U_7 U_5^\dagger)}{N_c^2 - 1},
\]

where \( U_\alpha \) is the fundamental Wilson line in the direction of \( \alpha \). We compute these probabilities as a function of

\[
\tau = \frac{\alpha_s}{\pi} \ln \frac{P_T}{E_{\text{out}}}
\]

The result for \( P_{qq}^8 \) for \( \theta_{\text{in}} = \pi/3 \) is shown in Fig. 1 together with its various approximations. Surprisingly, we find a very good agreement with the large-\( N_c \) approximation in which \( P \) is simply computed from the solution of the Banfi-Marchesini-Smye equation. A similar conclusion is reached for other channels including gluons in the initial state. While we do not fully understand the reason of this agreement at the moment, if it turns out to be a robust feature, it is good news because one can approximately get full-\( N_c \) results in hadron collisions using the known large-\( N_c \) frameworks.\(^1,5\)

References
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