Resummed Heavy Quark Production Cross Sections to Next-to-Leading Logarithm *

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The first resummation of leading logarithmic, LL, terms in heavy quark production was discussed in [1]. The analysis was based on the fact that the LL terms are identical to those in the Drell-Yan process. The importance of incorporating resummation effects in threshold production of heavy quarks in QCD was apparent. The order α_s^2 corrections to the Drell-Yan process allow a check of the NLL terms in the resummation formulae. However, this information cannot be used in heavy quark resummation since the color structure is more complicated. A resummation formalism which correctly incorporates the NLL heavy quark resummation near threshold has recently been presented [2].

We apply this new NLL resummation formalism to calculate the top quark production cross section at the Fermilab Tevatron and the bottom quark production cross section at fixed target energies. We are particularly interested in the size and therefore the phenomenological importance of the NLL terms with respect to the LL terms.

Our calculations are based on the factorization of soft gluons from high-energy partons in perturbative QCD. In [2] it was shown that to NLL it is possible to pick a color basis in which moments of the short distance cross section, $\hat{\sigma}_{ab}^{(IJ)}$, exponentiate so that

$$\tilde{\sigma}_{ab}^{(IJ)} = \int_0^1 dz z^{n-1} \hat{\sigma}_{ab}^{(IJ)}(z, \theta^*, \alpha_s(Q^2)) = h_I(\theta^*, Q^2) h_J^*(\theta^*, Q^2) e^{E_{IJ}^{(ab)}} . \quad (1)$$

The hard scattering prefactor is a product of contributions from the amplitude h_I and its complex conjugate h_J^*. The functions h_I and h_J^* have no collinear or soft divergences at the partonic threshold since these terms have been factored into the exponent E_{IJ} in eq. (1), given by

$$E_{IJ}^{(ab)} = -\int_0^1 dz \frac{z^{n-1}-1}{1-z} \times \Big\{ (2-r) \int_0^z \frac{dy}{1-y} g_1^{(ab)}(y, z, Q^2) + g_2^{(ab)}(z, Q^2) + g_3^{(I)}(z, Q^2, \theta^*) + g_3^{(J)*}(z, Q^2, \theta^*) \Big\}, \quad (2)$$

where g_1, g_2 and g_3 are functions of the running coupling constant α_s. The scheme dependent parameter r changes the lower limit of the y-integral in the $\overline{\rm MS}$ scheme.

The NLL functions $g_3^{(I)}$, depend on the color structure in the hard scattering so that $g_3^{(I)}$ is a function of both α_s and the angle θ^* between the incoming and outgoing partons. Although the eigenvalues are complex, the total g_3 contribution to $E_{IJ}^{(ab)}$ in eq. (2) is real.

We have investigated the numerical importance of the NLL terms in the resummation of subleading soft gluon contributions near threshold for heavy quark production cross sections. We have shown that these contributions are generally quite small for top production either because they are numerically small or due to cancellations between them. This result has only been demonstrated for the resummation method of [1] and at $\theta^* = 90^\circ$.

[1] E. Laenen, J. Smith, and W.L. van Neerven, Nucl. Phys. **B369**, 543 (1992).
[2] N. Kidonakis and G. Sterman, Phys. Lett. **B387**,867 (1996); N. Kidonakis, SUNY at Stony Brook Ph.D. Thesis (1996), hep-ph/9606474.

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