Hard QCD Dynamics

The application of perturbative QCD to short distance processes is a success story allowing, e.g., to understand the universality and Q^2 dependence of parton distributions. Nevertheless, even the dynamics of inclusive Deep Inelastic lepton Scattering (DIS) remains non-trivial in the $Q^2 \to \infty$ limit. Experimentally, this manifests itself in terms of diffractive DIS and nuclear shadowing, effects related to soft coherent scattering. In fact, the finite longitudinal coherence length $\sim 1/m_N x_B$ (a consequence of relativistic time dilation) allows soft rescattering of the struck parton in the target to be coherent with the hard virtual photon interaction [1]. The realization that the rescattering, which appears as an exponential line integral of the A^+ gluon field in the target matrix element, is not a gauge artifact but has observable consequences reopened the question of the universality of parton distributions.

Spin effects are sensitive to coherence. Following [1] it was quickly realized that rescattering would allow a non-vanishing single spin asymmetry at leading twist in semi-inclusive DIS. The very large asymmetries found in $pp^\uparrow \to \pi(x_F, k_\perp) + X$ at large x_F and $k_\perp$ of the pion are likely [2] to arise from another type of coherence effect which sets in as $x \to 1$. In [3] we investigated the factorization between hard and soft QCD dynamics in a "BB limit" where $Q^2(1-x)$ remains fixed as $Q^2 \to \infty$. In this limit the twist expansion fails and we found that the target matrix element takes the form of a novel multiparton distribution.

The dynamics of exclusive QCD processes remains poorly understood. Perturbative calculations typically underestimate exclusive form factors, suggesting important contributions from the end-points, where one parton carries most of the hadron momentum [4]. The "Bloom-Gilman duality" experimentally observed between inclusive parton distributions and individual resonances suggests that exclusive and inclusive hard dynamics are related [5]. The BB limit represents a step towards exclusive processes since the mass of the inclusive system remains finite in this limit.

Hadron form factors determine their charge density in the transverse (impact parameter) plane. This turns out to hold for an arbitrary scattering process initiated by a spacelike photon [6]. A two-dimensional Fourier transform *wrt.* the photon momentum, either of the amplitude or of the cross section, yields the distribution of the photon interaction vertex in impact parameter. The analysis can be done as a function of the final state configuration (multiplicity and relative momenta) and does not require large virtuality Q^2. The Fourier transform ranges over $0 \leq Q^2 \leq Q^2_{max}$, with the resolution in impact parameter estimated as $\Delta b \sim 1/Q_{max}$.

References

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