Fracture functions

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The QCD-improved parton model, through the factorization theorem for collinear singularities, allows to study hard lepton-hadron and hadron-hadron scattering computing experimental cross sections by means of convolutions of parton distributions (uncalculable, but process independent) with elementary cross sections (process dependent, but calculable).
In deep inelastic scattering processes for totally inclusive measurements, parton distributions play a central role and due to their universality can be used for the computation of different hard processes and/or at different scales.

Going to semi-inclusive reactions another set of uncalculable, universal functions, the fragmentation functions enter. Both of them obey integral-differential evolution equations, Altarelli-Parisi equations, and even in the presently extended kinematical region covered by HERA ep-collider the agreement between theory and experiment is fairly good.

Nevertheless the standard approach to semi-inclusive reactions based on fragmentation functions cannot be extended to the target fragmentation region at small p_T values (where p_T is the transverse momentum of the final state detected particle). The reason is the presence of collinear singularities that cannot be absorbed in a consistent way in parton or fragmentation distributions.

On the other side recently the ZEUS collaboration have analyzed DIS events with high energy neutrons in the final state in the very forward direction [1]. Analogously H1 experiment is going to measure also the angular dependence and with no doubts, the study of one-particle inclusive events in this small scattering angle region represents a new interesting task.

To this aim a new theoretical idea has been proposed and developed by Trentadue and Veneziano [2, 3]. This idea is based on the introduction of

a new set of uncalculable, but measurable, functions, the so-called fracture funcions $M_{i,h/N}(x,z)$, representing the probability to find a parton of flavour i with momentum fraction x (the struck parton) and a hadron h with momentum fraction z in the target N.
It has been shown [4] that these functions allow to absorb in a definite way all collinear singularities up to one-loop level in the redefinition of scale dependent fracture functions, extending the range of applicability of perturbative QCD to the whole kinematical region (current and target fragmentation region).
Among the features of fracture function there is the evolution equations they obey, these differ from the standard AP equations because of the presence of inhomogeneus terms. These new distributions can be related to the partonic content of the object exchanged between initial and final state, but the main difference with other factorization approaches is that fracture functions find their theoretical basis in pQCD and are not restricted to special kinematical conditions.

Fracture functions are non-perturbative quantities, i.e. they must be extracted from experiment. Some attempts to parametrize their functional form at a given scale have been done [5]. The simplest way is considering the pion pole contribution [6, 7, 8] for the process $\gamma^* + p \to n + X$ and modelling the fracture function through the flux of neutrons in the proton times the pion structure function. This may allow to study the importance of the different type of evolution. but it would be important also identifying new observables relevant to this issue.

References

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