Determination Of Fragmentation Functions And Their Uncertainties From $e^+ + e^- \to h + X$ Data

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Fragmentation functions are used in high-energy reaction processes with hadron production. They include hadron-production processes in electron-positron annihilation, electron, muon, and neutrino scattering from the proton or a nucleus, and proton-proton collisions. Such reactions are becoming increasingly important in hadron physics, for example, in investigating the origin of the proton spin. There are already a number of studies on such analyses. Widely used parametrizations are obtained by Kniehl, Kramer, and Pötter (KKP) [1] and also by Kretzer [2]. They analyzed hadron-production cross sections in e^+e^- annihilation. Despite the importance of the fragmentation functions, it is unfortunate that their uncertainties have not been estimated yet. In order to extract any information from the hadron-production processes, a reliability region of the fragmentation functions should be shown in comparison with actual data. In particular, it is known that there are large differences between the gluon fragmentation functions of KKP and Kretzer.

In this talk, we report our recent studies on the fragmentation functions and their uncertainties in both leading order (LO) and next-to-leading order (NLO) of running coupling constant α_s [3]. The fragmentation functions are expressed by a number of parameters:

$$D_i^h(z, Q_0^2) = a_i^h z^{b_i^h} (1-z)^{c_i^h}, \tag{1}$$

where a_i^h, b_i^h, and c_i^h are parameters to be determined from experimental data. We analyzed the data for hadron-production cross sections in electron-positron annihilation to obtain the optimum functions. The parameters are determined by minimizing the total χ^2 by comparing the theoretical calculations with the data. Uncertainties are then estimated by the Hessian method:

$$[\delta D_i^h(x)]^2 = \Delta\chi^2 \sum_{i,j} \left(\frac{\partial D_i^h(x,\hat{\xi})}{\partial \xi_i} \right) H_{ij}^{-1} \left(\frac{\partial D_i^h(x,\hat{\xi})}{\partial \xi_j} \right), \tag{2}$$

where H_{ij} is the Hessian and ξ_i is a parameter. The results indicate large uncertainties in disfavored functions. In particular, the gluon function has a large error band, which could result in large uncertainties in calculating various hadron-production processes.

References

[1] B. A. Kniehl, G. Kramer, and B. Pötter, Nucl. Phys. B582 (2000) 514.
[2] S. Kretzer, Phys. Rev. D62 (2000) 054001.
[3] M. Hirai, S. Kumano, T.-H.Nagai, and K. Sudoh, research in progress.