HKNS fragmentation functions and proposal for exotic-hadron search

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ABSTRACT

Fragmentation functions and their uncertainties are determined for pion, kaon, and proton by a global χ^2 analysis of charged-hadron production data in electron-positron annihilation and by the Hessian method for error estimation [1]. It is especially important that the uncertainties of the fragmentation functions are estimated in this analysis. The results indicate that the fragmentation functions, especially gluon and light-quark fragmentation functions, have large uncertainties at small Q^2. There are large differences between widely-used functions by KKP (Kniehl, Kramer, and Pötter), AKK (Albino, Kniehl, and Kramer), and Kretzer; however, they are compatible with each other and also with our functions if the uncertainties are taken into account. We find that determination of the fragmentation functions is improved in next-to-leading-order (NLO) analyses for the pion and kaon in comparison with leading-order ones. Such a NLO improvement is not obvious in the proton. Since the uncertainties are large at small Q^2, the uncertainty estimation is very important for analyzing hadron-production data at small Q^2 or p_T (Q^2, $p_T^2 << M_Z^2$) in lepton scattering and hadron-hadron collisions. A code is available for general users for calculating obtained fragmentation functions [1].

Next, it is proposed that fragmentation functions should be used to identify exotic hadrons [2]. As an example, fragmentation functions of the scalar meson $f_0(980)$ are investigated. The f_0 meson is considered as a candidate for an exotic hadron beyond the usual $q\bar{q}$ configuration because its strong-decay width is much larger than the experimental one [3] if it is an ordinary $q\bar{q}$ meson. The radiative decay $\phi \to f_0\gamma$ was proposed to find its internal structure [4], and subsequent measurements indicated tetraquark or $K\bar{K}$ structure. However, its structure has not been clearly determined yet. Here, we investigate the possibility of ordinary $q\bar{q}$, $s\bar{s}$, tetraquark, $K\bar{K}$ molecule, or glueball by the fragmentation functions of f_0. It is pointed out that the second moments and functional forms of the u- and s-quark fragmentation functions can distinguish the tetraquark structure from $q\bar{q}$. By the global analysis of $f_0(980)$ production data in electron-positron annihilation, its fragmentation functions and their uncertainties are determined. It is found that the current available data are not sufficient to determine its internal structure, while precise data in future should be able to identify exotic quark configurations.

References

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Code for calculating the fragmentation functions is available at
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