Determination on F and D with SU(3) Symmetry Breaking Effects and Δs Distributions in the Nucleon

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So far, to solve the puzzle of the proton spin crisis, several groups propose the longitudinally polarized parton distribution functions (pol-PDFs) with SU(3) flavor breaking for sea quark distributions, and calculate the quark spin content[1]. However, the values of F and D with exact SU(3) flavor symmetry are used in analyses of these pol-PDFs. As well-known, SU(3) flavor symmetry is not a good description because of rather large mass splitting between strange and nonstrange quarks. In addition, even SU(2) flavor symmetry is weakly broken. Therefore, it is important for understanding the nucleon spin structure to derive more realistic pol-PDFs using F and D including SU(3)/SU(2) symmetry breaking.

We propose a new formula for estimating F and D with comprehensively SU(3) and SU(2) symmetry breaking on baryon semi-leptonic decays, where all possible SU(3) and SU(2) breaking effects are induced from an effective interaction. Then most general SU(3) structure of the weak matrix elements between baryons can be written as [2]

$$\begin{aligned} &a_0\ \mathrm{Tr}(\bar{B}B\lambda_w) + b_0\ \mathrm{Tr}(\bar{B}\lambda_w B) + a\ \mathrm{Tr}(\bar{B}B\{\lambda_w,\mu\}) + b\ \mathrm{Tr}(\bar{B}\{\lambda_w,\mu\}B) \qquad (1)\\ &+c\ [\mathrm{Tr}(\bar{B}\lambda_w B\mu) - \mathrm{Tr}(\bar{B}\mu B\lambda_w)] + g\ \mathrm{Tr}(\bar{B}B)\mathrm{Tr}(\lambda_w\mu) + h\ [\mathrm{Tr}(\bar{B}\lambda_w)\mathrm{Tr}(B\mu) + \mathrm{Tr}(\bar{B}\mu)\mathrm{Tr}(B\lambda_w)]\ , \end{aligned}$$

where λ_w and μ denote the matrix element of the weak current and the matrix element giving the breaking of SU(3)/SU(2) flavor symmetry, respectively. B is the matrix representing the baryon octet. In SU(3) flavor symmetry with $q^2 \to 0$, i.e., four-momentum transfer being zero, the SU(3)-octet matrix elements between octet baryons can be written as the first two terms in eq.(1) with $a_0 = D - F$ and $b_0 = D + F$ in the absence of μ. Now we take μ as

$$\mu = \alpha\lambda_3 + \beta\lambda_8\ , \qquad (2)$$

in order to add the effect of the SU(3)/SU(2) flavor symmetry breakings with the Gell–Mann matrices λ_i. Since the ratios of axial-vector to vector form factors (g_1/f_1) are represented by F, D, and other parameters, we attmpt to estimate F and D with flavor symmetry breakings by χ^2–analyses using data of (g_1/f_1) and of the baryon semi-leptonic decay rates. The spin content of strange quarks Δs is derived from F and D obtained here. Furthermore the unmeasured values of (g_1/f_1) and (g_1) for other hyperon semi-leptonic decays are predicted from this new formula.

References

[1] For a recent review, see B. Lampe and E. Reya, Phys. Rep. **332**, 1 (2000).

[2] M. Ademollo and R. Gatto, Phys. Rev. Lett. **13**, 264 (1964).