TWIST-4 DISTRIBUTION AMPLITUDES OF THE PION AND THEIR IMPACT ON SOME EXCLUSIVE PROCESSES

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The leading and higher twist distribution amplitudes (DAs) of hadrons are important ingredients in investigation of numerous exclusive processes within QCD. The traditional method for the description of DA is founded on the conformal symmetry of the QCD Lagrangian. In the framework of this approach the leading and higher twist DAs are expanded over the conformal spin. Because of the increasing number of parameters at higher conformal spins and practical difficulties in phenomenological applications, one has to restrict one's self by only the first few terms in the conformal expansion of DAs. At the same time, the sup-pression of higher spin contributions and the convergence of conformal expansion at present experimentally accessible energy regimes is by no means obvious and may be wrong. Therefore, one needs to draw new approaches to clarify this problem.

The renormalon model of higher twist DAs [1] pursues to test precisely this issue, that is to set a plausible upper bound for the possible contributions of higher conformal spins that so far escaped attention.

In the renormalon approach the light mesons' twist-3 and -4 DAs are determined in terms of the corresponding leading twist DAs. Within this approach the pion two-particle twist-4 DAs $\varphi_1^{(4)}(u)$ and $\varphi_2^{(4)}(u)$ are given by the expressions

$$\varphi_{1(2)}^{(4)}(u,Q^2) = \delta^2 u\bar{u}\sum_{n=1}^{3} L_n(Q^2)\varphi_n^{1(2)}(u), \qquad (1)$$

where $\delta^2 = 0.2\,GeV^2$ is the parameter estimated from the two-point QCD sum rules, and $\bar{u} \equiv 1-u$. The functions $L_n(Q^2)$ determine the evolution of the DAs on the factorization scale $\mu_F^2 = Q^2$,

$$L_1(Q^2) = 1 + 6b_2(Q^2) + 15b_4(Q^2),$$
$$L_2(Q^2) = -30\left[b_2(Q^2) + 7b_4(Q^2)\right],\ L_3(Q^2) = 630b_4(Q^2). \qquad (2)$$

The components $\varphi_n^{1(2)}(u)$ of the twist-4 DAs are given as:

$$\varphi_1^1(u) = u\left[\ln u - Li_2(u)\right] + \bar{u}\left[\ln\bar{u} - Li_2(\bar{u})\right] - u\bar{u} + \frac{\pi^2}{6},$$
$$\varphi_1^2(u) = \left(-\frac{1}{2}u^2 + \frac{1}{3}u^3\right)\ln u + \left(-\frac{1}{2}\bar{u}^2 + \frac{1}{3}\bar{u}^3\right)\ln\bar{u} - \frac{1}{6}u\bar{u} - \frac{3}{4}u^2\bar{u}^2, \qquad (3)$$
$$\varphi_1^3(u) = \left(-\frac{1}{6}u^3 + \frac{1}{4}u^4 - \frac{1}{10}u^5\right)\ln u + \left(-\frac{1}{6}\bar{u}^3 + \frac{1}{4}\bar{u}^4 - \frac{1}{10}\bar{u}^5\right)\ln\bar{u} - \frac{1}{60}u\bar{u} + \frac{1}{10}u^2\bar{u}^2 - \frac{17}{36}u^3\bar{u}^3,$$

and

$$\varphi_1^2(u) = u^2\ln u + \bar{u}^2\ln\bar{u} + u\bar{u},\ \varphi_2^2(u) = -\frac{1}{3}u^2\bar{u}^2,\ \varphi_2^3(u) = -\frac{1}{20}u^2\bar{u}^2 - \frac{1}{10}u^3\bar{u}^3. \qquad (4)$$

These DAs can be employed for computation of the pion electromagnetic $F_\pi(Q^2)$ and transition $F_{\pi\gamma}(Q^2)$ form factors (FFs) within the light–cone sum rules method. Our aim is to compare the light–cone sum rules predictions for the electromagnetic and transition FFs with experimental data and extract constraints on the parameters $b_2^0 \equiv b_2(Q^2 = 1Gev^2)$, $b_4^0 \equiv b_4(Q^2 = 1Gev^2)$ of the pion leading twist (twist-2) DA $\varphi_\pi(u,Q^2)$,

$$\varphi_\pi(u,Q^2) = 6u\bar{u}\sum_{n=1}^{3} L_n(Q^2)(u\bar{u})^n \ . \qquad (5)$$

The values obtained from analysis of the pion electromagnetic FF are [2]:

$$b_2^0 = 0.2 \pm 0.03, \quad b_4^0 = -0.03 \pm 0.06 \ . \qquad (6)$$

From consideration of the transition FF we get [3]

$$b_2^0 = 0.27, \quad b_4^0 = -0.3\,, \qquad (7)$$

where the corresponding 1σ region of the parameters has a complicated form. This 1σ area overlaps with (5) in the region determined by the following values of the parameters

$$b_2^0 \cong 0.2 \div 0.23, \quad b_4^0 \cong -0.05 \div (-0.09)\,. \qquad (8)$$

Equation (8) gives our estimate for the parameters in the pion twist-2 DA.

References:

[1] V. M. Braun, E. Gardi and S. Gottwald, Nucl. Phys. **B685**, 171 (2004).
[2] S. S. Agaev, Phys. Rev. D**72**, 074020 (2005).
[3] S. S .Agaev, Phys. Rev. D**72**, 114010 (2005); Erratum-ibid. D**73,** 059902 (2005).