Adler-Bardeen Theorem for the Axial Anomaly and the First Moment of the Polarized Virtual Photon Structure Function

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In recent years there has been growing interest in the study of the spin structure of the photon. In particular, the first moment of the polarized photon structure function g_1^γ has attracted much attention in connection with its relevance to the QED and QCD axial anomaly. When the target photon is far off-shell in the kinematical region,

$$\Lambda^2 << P^2 << Q^2 \ , \tag{1}$$

where $-P^2$ ($-Q^2$) is the mass squared of the target (probe) photon and Λ is the QCD scale parameter, we can calculate structure functions by the perturbative method without any experimental input.

We report our recent analysis of the next-to-next-to-leading order ($\alpha\alpha_s^2$) corrections to the first moment of the polarized virtual photon structure function $g_1^\gamma(x, P^2, Q^2)$ in the kinematical region (1). In the framework of the operator product expansion of two electromagnetic currents, the operators which contribute to the first moment of g_1^γ are only the flavor singlet and nonsinglet quark axial vector currents. To evaluate the photon matrix elements of these operators, we make full use of the Adler-Bardeen (AB) theorem for the axial vector current, which states that the anomaly term is not affected by higher-order radiative corrections. The use of the AB theorem simplifies computation enormously and we could evaluate the photon matrix elements (finite terms) of the flavor singlet and nonsinglet quark axial vector currents up to the three-loop-level, which are necessary ingredients for the present analysis.

The corrections $\alpha\alpha_s^2$ are found to be about 3% of the sum of the leading order (α) and the next-to-leading order ($\alpha\alpha_s$) contributions, when Q^2=30~100 GeV^2 and P^2=3 GeV^2, and the number of active quark flavors is three to five.