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Bjorken sum rule with analytic coupling at low Q^2 values

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Polarized Bjorken sum rule (BSR) $\Gamma_1^{p-n}(Q^2)$ [1, 2], i.e. the difference between the first moments of the spin-dependent structure functions (SFs) of a proton and neutron, is a very important space-like QCD observable [3, 4]. Its isovector nature facilitates its theoretical description in perturbative QCD (pQCD) in terms of the operator product expansion (OPE), compared to the corresponding SF integrals for each nucleon. Experimental results for this quantity obtained in polarized deep inelastic scattering (DIS) are currently available in a wide range of the spacelike squared momenta Q^2: 0.021 $\text{GeV}^2 \leq Q^2 < 5$ GeV^2 (see [5] and references therein). In particular, the most recent experimental results [5] with significantly reduced statistical uncertainties, derived mainly from the Jefferson Lab EG4 experiment on polarized protons and deuterons and E97110 one on polarized ^3H, make BSR an attractive quantity for testing various pQCD generalizations at low Q^2 values: $Q^2 \leq 1$ GeV^2.

Theoretically, pQCD (with OPE) in the $\overline{MS}$-scheme was the usual approach to describing such quantities. This approach, however, has the theoretical disadvantage that the running coupling constant $\alpha_s(Q^2)$ has the Landau singularities for small Q^2 values: $Q^2 \leq 0.1$ GeV^2, which makes it inconvenient for estimating spacelike observables at small Q^2, such as BSR. contributions to the BSR [21] with good results. In the recent years, the extension of pQCD couplings for low Q^2 without Landau singularities called (fractional) analytic perturbation theory [(F)APT)] [6–13] (or the minimal analytic (MA) theory [14]), were applied to match the theoretical OPE expression with the experimental BSR data [15–23].

In the present paper the experimental data obtained for the polarized Bjorken sum rule $\Gamma_1^{p-n}(Q^2)$ for small values of Q^2 are approximated by the predictions obtained in the framework of analytic QCD up to the 5th order perturbation theory, whose coupling constant does not contain the Landau pole. We found an excellent agreement between the experimental data and the predictions of analytic QCD, as well as a strong difference between these data and the results obtained in the framework of perturbative QCD.

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