QCD Analysis of Polarized Deep Inelastic Scattering Data and Parton Distributions

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Abstract

A QCD analysis of the world data on inclusive polarized deep inelastic scattering of leptons on nucleons is presented in leading and next-to-leading order. The analysis is based on 433 published data points of asymmetry data, i.e. g_1/F_1 or A_1, above $Q^2 = 1.0\ GeV^2$. The QCD fits are performed on g_1 which is evaluated from the asymmetry data using parametrizations for the unpolarized structure functions F_2 and R.

The shape chosen for the parametrization of the polarized parton distributions at the input scale of $Q_0^2 = 4\ GeV^2$ is

$$x\Delta q_i(x,Q_0^2) \quad = \quad \eta_i A_i x^{a_i}(1-x)^{b_i}(1+\gamma_i x+\rho_i x^{\frac{1}{2}}),$$

where the normalization constant A_i is defined such that η_i is the first moment (x integral) of the corresponding polarized parton distribution. SU(3) flavour symmetry and a flavour symmetric sea are assumed. The following parton densities are derived: Δu_v, Δd_v, $\Delta\bar{q}$, and ΔG. Given the present accuracy of the data the number of parameters for each distribution had to be restricted to three. In addition the QCD parameter Λ_{QCD} was determined. Emphasis is put on the calculation of the fully correlated 1σ error bands for the polarized parton distributions, which are directly applicable to determine experimental errors of other polarized observables. While the quality of the data is sufficient to determine Δu_v and Δd_v with rather good accuracy, ΔG and $\Delta\bar{q}$ have much broader error bands, essentially due to the lack of data at low x. The polarized parton distributions derived are within the error bands compatible with those from other QCD analyses, as e.g. with the ones of the GRSV and the AAC group. The measured structure function g_1^p is rather well described both as function of x and of Q^2. Evolving the polarized parton distribution to Q^2 values up to $10,000\ GeV^2$ one observes that even within the error band ΔG stays *positive* while $\Delta\bar{q}$ develops a trend to change sign and becomes slightly positive towards higher Q^2 values and for $x \gtrsim 0.1$ within the errors.

The value of $\alpha_s(M_z^2)$ is determined by fitting Λ_{QCD}. The impact of the variation of both the renormalization and factorization scales on the value of α_s is studied. The following result for $\alpha_s(M_Z^2)$ was obtained which is within the errors compatible with the world average:

$$\alpha_s(M_Z^2) = 0.114\ {}^{+0.004}_{-0.005}\ (\text{fit})\ {}^{+0.005}_{-0.004}\ (\text{fac})\ {}^{+0.008}_{-0.005}\ (\text{ren}).$$

Finally first steps in a factorization–scheme invariant QCD analysis based on the observables $g_1(x,Q^2)$ and $dg_1(x,Q^2)/d\log(Q^2)$ in next-to-leading order were performed. A downward shift of 12 MeV in Λ_{QCD} was found yielding a similar result for $\alpha_s(M_Z^2)$ as obtained in the standard analysis.