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QCD AND ELECTROMAGNETIC EFFECTS IN POLARIZATION ASYMMETRY OF DEEP INELASTIC LEPTON-NUCLEON SCATTERING UNDER EMS EXPERIMENT CONDITIONS

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The results of experiment carried out by EMC in CERN are discussed, as regards the influence of radiative effects on the observable parameter - spin asymmetry.

Experiments on deep inelastic scattering (DIS) of leptons on nucleons are a convenient tool for a perturbation QCD test. Of great importance are experiments with polarized particles, which allow us to study a spin proton content (see, for example, [1,2]), as they may provide a full verification of this theory.

In a recent EMC experiment [3], the spin photon-proton asymmetry was measured

$$A_1 = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} \tag{1}$$

in deep inelastic scattering of longitudinally polarized muons on longitudinally polarized protons in the region of $0.01 < x < 0.7$ and $1.5 < Q^2 < 70$ $(GeV/s)^2$. Here $\sigma_{1/2}(\sigma_{3/2})$ are the photoabsorption cross-sections, when the total angular moment projection of the "virtual photon-nucleon" system onto the direction of a virtual photon momentum is equal to 1/2(3/2).

Data for A_1 agree with earlier experiments, made in SLAC over the whole range of coinciding X values (Fig.1). However, at $X < 0.2$, the EMC data give much smaller values A_1, than one would expect in the model [4] (the full curve in Fig.1), based on standard concepts of the quark structure

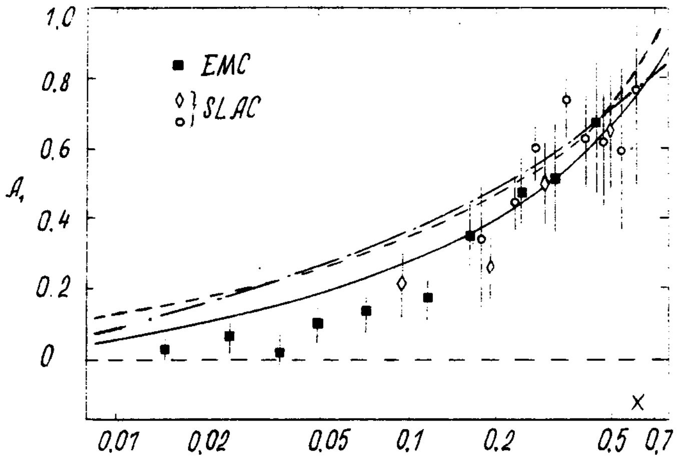

Fig.1. Asymmetries, obtained from formulas of [6-8], allowing for the total electromagnetic correction of the α order ($\overline{A}_1$, broken line) and without this correction (A_1, dot-and-dash line) depending on X at a quark mass of 0.33 GeV, muon energy 200 GeV, $R = \sigma_L/\sigma_T = 0$ and with polarized quarks spectrum from [4]. Values X, Q^2, experimental dots and the full curve belong to [3]

of a nucleon. In this model the polarization asymmetry is equal to

$$A_1 = \frac{2xq_1^p(x)}{F_2^p(x)} = \frac{cos2\theta[\frac{4}{9}u_v(x) - \frac{1}{3}d_v(x)]}{\frac{4}{9}u_v(x) + \frac{1}{9}d_v(x) + \frac{4}{3}s(x)}, \tag{2}$$

where $u_v(x)$, $d_v(x)$, $s(x)$ - are the valency and "sea" nonpolarized quark distributions

$$cos2\theta = [0.051x^{-1/2}(1 - x^2) + 1]^{-1}.$$

From the A_1 data in the experiment under consideration the function $g_1^p(x)$ was obtained. But of particular interest for theory is, however, the integral

$$I = \int_0^1 g_1^p(x)dx, \tag{3}$$

for which value $0.114 \pm 0.012 \pm 0.026$ has been found [3], whereas the Ellis-Jaffe sum rule gives $I = 0.189 \pm 0.005$. The total spin projection of all quarks and antiquarks onto the polarized proton spin direction, calculated with the help of QCD sum rules (Bjorken, Ellis-Jaffe), turned out to be close to zero. This basic result of the EMC experiment, paradoxical from a physical intuition stand-point ("spin crisis"), proved to be very interesting. A number of attempts were made to give a good fit of experimental data to theory. Experimental data interpretations [3] were proposed, which were connected with Skirme model by an orbital quark moment, by a large negative contribution of strange quark polarization ("sea"), by the presence of an axial anomaly, inducing a considerable contribution of gluons into proton spin; by chiral and soliton bag models, etc...

Nevertheless, the "spin crisis" problem cannot be considered exhaustive, as, for example, a great number of approaches testify to uncertainty in the EMC test interpretation.

In this situation, it is natural to study the influence of radiative effects on the observable parameter, i.e. polarization asymmetry A_1.

Allowing for the total electromagnetic correction of lower order, asymmetry A_1 is equal to:

$$\overline{A}_1 = A_1 \frac{1+\delta_p}{1+\delta_a} , \tag{4}$$

where $\delta_{a,p} = \delta^l_{a,p} + \delta^h_{a,p}$, $\delta^{l(h)}$ - is the electromagnetic α - order correction to a lepton (hadron) current, "a", "p" refer to the quantities, characterizing DIS of nonpolarized and polarized initial particles, respectively. A_1 is determined from formulas (1), (2). Correction δ_a was calculated in [5], and δ_p - in [6-8]. It is clear from Fig.1, that asymmetry A_1 agrees with experiment at $X > 0.15$. Allowing for the electromagnetic lower order correction, whose magnitude does not exceed 2% (only at $X \approx 0.015$ it is $\approx 12\%$), does not lead to any noticeable change in the behaviour of A_1 in the measured X region. This is in conformity with the results of [7-9], where it is shown, that corrections to asymmetry become important at $y \geq 0.8$, reaching tens of percent for small X and Y, close to 1.

In the given experiment, for example, at a muon energy of 200 GeV, the values of Y do not exceed 0.7. Comparing A_1 and a theoretical curve [3], one can see, that they are identical in behaviour, but differ in magnitude by $5 - 10\%$, though both the calculations are based on the model [4]. This is attributed, evidently, to application of a different distribution of nonpolarized quarks from that given in [4].

The QCD effects due to quark interaction (the contribution of weak interactions is rather small, as $Q^2 \ll M_Z^2$), also make a contribution into radiative processes for the $l^\pm N$ - DIS.

QCD-corrections may be arbitrarily divided into three groups:

1. Corrections due to radiation of braking gluons by a quark, which suffers collision with a lepton. It is precisely these effects that cause violation of scaling, that is, they provide Q^2 - dependence of structure functions (or quark distribution functions).

2. The rest of contributions, pertaining to the quark interaction with a lepton (vertex corrections etc...). The effects, such as 1 and 2 are the ones we usually assume to be QCD-corrections, which can be calculated with the aid of perturbation theory.

3. Nonperturbative effects due to the interaction of a quark participating in scattering and a quark in nucleon being in a bonded state (higher twist effects).

It is known, that the contribution of corrections of the first type into asymmetry is not large (Fig.2). It may be effectively determined from a replacement $f_q(x) \to f_q(x, Q^2)$ (f_q is the distribution function of a q-quark) in formula (2).

For the purpose of estimating contributions of the QCD-effects into A_1, we have calculated the asymmetry based on effective Hamiltonian of the interaction of leptons with quarks [10,11]. Calculations show, that (see Fig.2) the contribution of the leading logarithmic QCD corrections is substantial only for $X \geq 0.2$, $Y \to 0$. At $X \to 0$, it is very small. This also holds true, when we take into account structure functions [12] containing the Q^2 - dependence. At the same time, allowing for the contributions of higher twists [13,14] becomes important, as differences in experiment and theory occur at small Q^2. Here dynamical power corrections may be rather large.

It is shown in [14], that in the region of Q^2, typical of the EMC experiment, there must be large nonperturbative corrections, associated with the Gerasimov-Drell-Hearn sum rule. As a result, the authors of this work come to the conclusion, that EMC data are not in disagreement with the situation, when quarks take away ~ 50% of proton spin, and the strange quark sea contribution is small.

Thus analysis of radiative corrections to polarization asymmetry A_1 shows, that for the measuring region of X and Q^2 allowing for electromagnetic and perturbation QCD effects does not result in the agreement of the EMC data and theory for small X.

There is no doubt, in this situation,a realistic calculation of the higher twist effect contribution is needed.

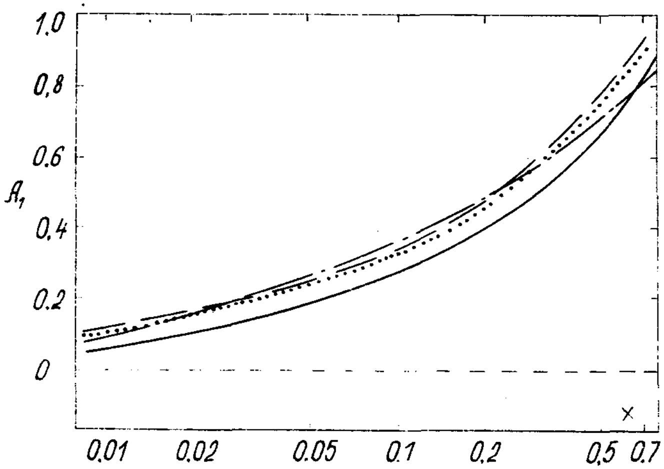

Fig.2. Asymmetry A_1, allowing for QCD effects and parton spectra, taken from [4] (broken line) and [12] (dot line). The other notations are the same, as in Fig.1

In our opinion, the problem of simultaneous allowing for electroweak and QCD radiative effects has become also actual, for example, in the framework of a standard theory of $SU(3) \times SU(2) \times U(1)$.

In conclusion, we should note, that in order to obtain unambigous experimental data on spin asymmetry in μN -DIS, both the adequate of radiative corrections to data, based on a realistic allowing for radiative effects discussed and additional tests [15] are necessary. They will provide a more accurate measurement not only of $g_1^p(x)$, but also of the analogous function $g_1^n(x)$, for a neytron. The measurement of the latter one is required (see, for example [15,16] for the verification of a number of theoretical predictions, including that of the Bjorken sum rule.

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THE POSSIBILITIES OF THE t QUARKS SEARCH AT THE FUTURE UNK COLLIDER

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The t-quark production in pp-collisions $\sqrt{s} = 2.2\ TeV$ (in the UNK collider operational mode) have been investigated. The conditions for distinguishing the signal from t-quarks from the background (W+n(jet) production) have been analyzed. The possibility to discriminate in principle the signal from t up to the masses $m_t = 200\ GeV$ has been demonstrated. The condition under which the t-quark masses can be determined proceeding from the peaks in the invariant mass spectra has also been treated.

1. INTRODUCTION

The minimum Standard Model with one Higgs doublet and three generations contains many unambiguous indications to the existence of t-quark. First of all, the t-quark should be $SU(2)$ doublet and singlet of the third generation. It is also implied by the forward-backward asymmetry in the b jet distribution in the $e^+e^- \to b\bar{b}$ process, which leads to the axial charge of b-quark $a_b = -1.11 \pm 0.29$ [1], which should be compared with $a_b = -1$, if b_l is the doublet member and $a_b = 0$, if b_l is a signlet member. Pure theoretical considerations also demand the existence of the t-quark since its existence allows one to reduce the chiral anomalies in the third generation. Finally, the suppression of flavour changing neutral currents with the left component of b-quark - b_l , with the GIM mechanism also requires the presence of a