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EFFECTS OF WEAK NEUTRAL CURRENTS IN THE SEMI-INCLUSIVE $l^{\mp}N \to l^{\mp}hX$ REACTIONS

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The investigation of electroweak asymmetries in the deep-inelastic scattering of polarized lepton on polarized nucleons is carried out in framework of the standard theory and in the quark-parton model. The expressions for left-right, polarization, charge-polarization and charge asymmetries are obtained.

1. The standard model (SM) of the electroweak interactions of the elementary particles [1] has achieved a great success in the description of series of the experiments, which have been carried out in the various laboratories of the world. In particular, one of its exact checking has been alone on the e^-e^+ – colliders LEP, SLC and TRISTAN, as the result of which the agreement with the experimental data has been obtained. Alongside with e^-e^+ - annihilation the deep-inelastic scattering processes of the polarized leptons on the polarized nucleons play the important role in the check of standard theory and they are intensive investigated experimentally at the present time [2-6].

In the present paper the effects of weak neutral currents (SNT) in the semi-inclusive reactions are considered

$$\ell^{\mp} + N \to (\gamma^*; Z^0) \to \ell^{\mp} + h + X\,, \qquad (1)$$

in which the lepton and the picked out inclusive adron h are registered on the coincidence and X is the system of non-detectering adorns.

The especial attention is paid to p-add polarization effects. The polarization fenomena are more sensitive to the reaction mechanism and allow to recognize the contributes of SNT easily. The investigation of the polarization particle correlations give the possibility to check the series of OCD predictions, to calculate the spin structure functions of adrons, to define the momentum distribution of the quarks and gluon inside of the polarized nucleons. The study of the polarization phenomena has got the special actuality last years, because of the obtaining of the high-energy beams of the polarized leptons and the creation of the polarized proton –antiproton beams and targets.

The Feynman diagrams for lepton creation of the inclusive adron h are presented in the fig.1.

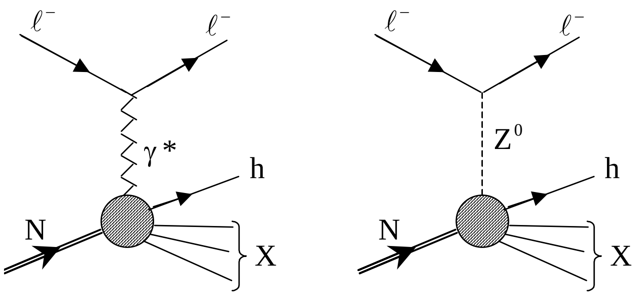

Fig. 1. Deep-inelastic leptocreation of adron h: $\ell^{\mp}N \to \ell^{\mp}hX$.

2. At first we consider the parton subprocess

$$\ell^- + q \to (\gamma^*; Z^0) \to \ell^- + q, \qquad (2)$$

and discuss the series of its qualitative properties at high energies. It is easy to be convinced, that in the process (2) of the exchange of proton and Z^0- bozon the spiralities of lepton and quark must be kept separately. That is why the process (2) is characterized by four independent spiral amplitudes F_{LL},F_{RR},F_{RL} and F_{LR} (the first and the second indexes show the spiralities of lepton and quark correspondingly), that describe the following reactions:

$$\ell^-_L + q_L \to \ell^-_L + q_L\,,\ \ \ell^-_R + q_R \to \ell^-_R + q_R\,,$$
$$\ell^-_L + q_R \to \ell^-_L + q_R\,,\ \ \ell^-_R + q_L \to \ell^-_R + q_L\,.$$

In the SM framework the spiral amplitudes are defined by expressions:

$$F_{\alpha\beta} = \frac{Q_e Q_q}{t} + \frac{g^{\ell}_{\alpha} g^{q}_{\beta}}{t - M_Z^2} \quad (\alpha,\beta = L;R)$$

where $t = q^2$ is the square of the transfer momentum, M_Z is the mass of Z^0- bozon, g^{ℓ}_L and g^{ℓ}_R (g^q_L and g^q_R) –are the chiral bond constants of lepton (quark) with Z^0- bozon, the values of which are equal to:

$$g^{\ell}_L = \frac{-1/2 + x_w}{\sqrt{x_w(1-x_w)}}\,,$$

$$g^{\ell}_R = \sqrt{\frac{x_w}{1-x_w}}\,, \qquad (4)$$

$$g^q_L = \frac{(T_3 - Q_q x_w)}{\sqrt{x_w(1-x_w)}}\,,$$

$$g^q_R = -Q_q\sqrt{\frac{x_w}{1-x_w}}$$

where $x_w = sin^2\theta_w$ is the Weinberg's parameter; Q_q is the electric charge, T_3 is the third projection of the weak isospine of quark q .Let us give the cross-section of the subprocess (2) at the determined values of the spiralities of initial and final particles.

$$\frac{d\sigma}{dy}(\ell^-_\alpha q_\alpha \to \ell^-_\alpha q_\alpha) = 4\pi\alpha^2 sF^2_{\alpha\alpha},\ (\alpha = L\ or\ R),$$
$$\frac{d\sigma}{dy}(\ell^-_\alpha q_\beta \to \ell^-_\alpha q_\beta) = 4\pi\alpha^2 s(1-y)^2 F^2_{\alpha\beta},\ (\alpha = L\ or\ R;\ \beta = R\ or\ L), \quad (5)$$

where s is the square of the total energy of the system $\ell^- q$ in c.m.s the variable y is connected with the lepton scattering angle $\tilde{\theta}$ in c.m.s by the following relation

$$y = -\frac{t}{s} = \frac{1}{2}(1-\cos\tilde{\theta}).$$

The differential cross-section of the parton subprocess (2) is given by the following expression

$$\frac{d\sigma}{dy}(\ell^- q \to \ell^- q) = \pi\alpha^2 s\{(1-\lambda)(1-h_q)F^2_{LL} + (1+\lambda)(1+h_q)F^2_{RR} + $$
$$+ [(1-\lambda)(1+h_q)F^2_{LR} + (1+\lambda)(1-h_q)F^2_{RL}](1-y)^2\} \quad (6)$$

where λ and hq are spiralities of lepton and quark.

3. Let us consider the distribution function of quark (anti-quark) in the polarized nucleon $f^{N(h_N)}_{q(h_q)}(x)$ $\left(f^{N(h_N)}_{\bar{q}(h_{\bar{q}})}(x)\right)$, which describes the probability of quark q (antiquark $\bar{q}$) revealing in the nucleon with the momentum part x, having the spirality $h_q\,(h_{\bar{q}})$. This function satisfies the following equations:

$$f^{N(-h_N)}_{q(-h_q)}(x) = f^{N(h_N)}_{q(h_q)}(x),$$
$$f^{N(+1)}_{q(+1)}(x) + f^{N(+1)}_{q(-1)}(x) = f_q(x), \quad (7)$$

where $f_q(x)$ presents itself as the usual distribution function of quark q in nucleon. According to QCD the quark distribution functions in nucleon depend on the square of the transfer momentum $q^2:\ f_q(x, q^2)$ also.

In SM frameworks the differential cross-section of hall-inclusive reaction $\ell^- N \to \ell^- hX$ must be written in the following form:

$$\frac{d\sigma^{(-)}}{dxdydz} = \sum_{q,\,h_q} f^{N(h_N)}_{q(h_q)}(x, q^2)D^h_q(z)\frac{d\sigma(\ell^- q \to \ell^- q)}{dy} + \sum_{\bar{q},\,h_{\bar{q}}} f^{N(h_N)}_{\bar{q}(h_{\bar{q}})}(x, q^2)D^h_{\bar{q}}(z)\frac{d\sigma(\ell^-\bar{q} \to \ell^-\bar{q})}{dy} =$$
$$= 2\pi\alpha^2 sx\sum_q\{f_q(x, q^2)D^h_q(z)[(1-\lambda)(F^2_{LL} + (1-y)^2F^2_{LR}) + (1+\lambda)(F^2_{RR} + (1-y)^2F^2_{RL})] +$$
$$+ f_{\bar{q}}(x, q^2)D^h_{\bar{q}}(z)[(1-\lambda)(F^2_{LR} + (1-y)^2F^2_{LL}) + (1+\lambda)(F^2_{RL} + (1-y)^2F^2_{RR})] - \quad (8)$$
$$- h_N\Delta f_q(x, q^2)D^h_q(z)[(1-\lambda)(F^2_{LL} - (1-y)^2F^2_{LR}) - (1+\lambda)(F^2_{RR} - (1-y)^2F^2_{RL})] -$$
$$- h_N\Delta f_{\bar{q}}(x, q^2)D^h_{\bar{q}}(z)[(1-\lambda)(F^2_{LR} - (1-y)^2F^2_{LL}) - (1+\lambda)(F^2_{RL} - (1-y)^2F^2_{RR})]\}$$

Where

$$\Delta f_q(x, q^2) = f^{N(+1)}_{q(+1)}(x, q^2) - f^{N(+1)}_{q(-1)}(x, q^2),$$

$$s = (P+k)^2;\ x = -q^2/2(P\cdot q);\ y = (P\cdot q)/(P\cdot k),\ z = (P\cdot p_h)/(P\cdot q),$$

h_N is the nucleon spirality; k, P and p_h are 4 momentums of an initial lepton, nucleon and final adron h; q-k-k' is 4-vector of the momentum transfer; $D^h_q(z)\,(D^h_{\bar{q}}(z))$ is the fragmentation function of quark (antiquark) in adron h.

The differential cross-section of process $\ell^+ N \to \ell^+ hX$ must be obtained from (8) with the help of neutral substitutions $F_{R\beta} \leftrightarrow F_{L\beta}$ (β=R; L):

$$\frac{d\sigma^{(+)}}{dxdydz}=2\pi\alpha^2 sx\sum_q\{ f_q(x,q^2)D_q^h(z)[(1-\lambda)(F_{RL}^2+(1-y)^2F_{RR}^2)+(1+\lambda)(F_{LR}^2+(1-y)^2F_{LL}^2)]+$$

$$+f_{\bar q}(x,q^2)D_{\bar q}^h(z)[(1-\lambda)(F_{RR}^2+(1-y)^2F_{RL}^2)+(1+\lambda)(F_{LL}^2+(1-y)^2F_{LR}^2)]-$$

$$-h_N\Delta f_q(x,q^2)D_q^h(z)[(1-\lambda)(F_{RL}^2-(1-y)^2F_{RR}^2)-(1+\lambda)(F_{LR}^2-(1-y)^2F_{LL}^2)]- \qquad (9)$$

$$-h_N\Delta f_{\bar q}(x,q^2)D_{\bar q}^h(z)[(1-\lambda)(F_{RR}^2-(1-y)^2F_{RL}^2)-(1+\lambda)(F_{LL}^2-(1-y)^2F_{LR}^2)]\}$$

The W.N.C displays can be observed by the means of revealing of character P - and S - odd effects. Such effects are:

1. left -right asymmetries

$$A^{(\mp)}(\ell_L^{\mp}-\ell_R^{\mp})=[\sigma_L^{(\mp)}-\sigma_R^{(\mp)}]/[\sigma_L^{(\mp)}+\sigma_R^{(\mp)}], \qquad (10)$$

$$A^{(\mp)}(\ell_L^{\mp}-\ell_R^{\pm})=[\sigma_L^{(\mp)}-\sigma_R^{(\pm)}]/[\sigma_L^{(\mp)}+\sigma_R^{(\pm)}]; \qquad (11)$$

2. polarization asymmetries

$$A_p^{(\mp)}=[\sigma_{RR}^{(\mp)}-\sigma_{LL}^{(\mp)}]/[\sigma_{RR}^{(\mp)}+\sigma_{LL}^{(\mp)}], \qquad (12)$$

$$A_a^{(\mp)}=[\sigma_{RL}^{(\mp)}-\sigma_{LR}^{(\mp)}]/[\sigma_{RL}^{(\mp)}+\sigma_{LR}^{(\mp)}]. \qquad (13)$$

3. charge-polarization asymmetries

$$B_p^{(\mp)}=[\sigma_{RR}^{(\mp)}-\sigma_{LL}^{(\pm)}]/[\sigma_{RR}^{(\mp)}+\sigma_{LL}^{(\pm)}], \qquad (14)$$

$$B_a^{(\mp)}=[\sigma_{RL}^{(\mp)}-\sigma_{LR}^{(\pm)}]/[\sigma_{RL}^{(\mp)}+\sigma_{LR}^{(\pm)}]. \qquad (15)$$

4. Charge asymmetries

$$C_{\alpha\beta}=[\sigma_{\alpha\beta}^{(-)}-\sigma_{\alpha\beta}^{(+)}]/[\sigma_{\alpha\beta}^{(-)}+\sigma_{\alpha\beta}^{(+)}],\ (\alpha,\beta=R;\ L) \qquad (16)$$

Here $\sigma_L^{(-)}=\dfrac{d\sigma_L^{(-)}}{dxdydz}$ and $\sigma_R^{(-)}=\dfrac{d\sigma_R^{(-)}}{dxdydz}$; ($\sigma_L^{(+)}$ and $\sigma_R^{(+)}$)-differential cross-sections semi-inclusive GNR of the left- and right-polarized lepton (antilepton) on nucleons, $\sigma_{RR}^{(\mp)}$, $\sigma_{LL}^{(\mp)}$, $\sigma_{RL}^{(\mp)}$ and $\sigma_{LR}^{(\mp)}$ are cross-sections of process (1) at the spiralities of collising particles $\lambda=1$, $h_N=1$; $\lambda=-1$, $h_N=-1$; $\lambda=-1$, $h_N=-1$ and $\lambda=-1$, $h_N=1$.

The electroweak asymmetries (10)-(16) are expressed by the spiral amplitudes $F_{\alpha\beta}$, as it takes place in the electron-position annihilation processes [7-9]. For example, the left-right asymmetry $A(\ell_L^- - \ell_R^+)$ is defined by the following expression

$$A(\ell_L^- - \ell_R^+)=\frac{1-(1-y)^2}{1+(1-y)^2}\,\frac{\sum_q(F_{LL}^2-F_{LR}^2)[f_q(x,q^2)D_q^h(z)-f_{\bar q}(x,q^2)D_{\bar q}^h(z)]}{\sum_q(F_{LL}^2+F_{LR}^2)[f_q(x,q^2)D_q^h(z)+f_{\bar q}(x,q^2)D_{\bar q}^h(z)]}. \qquad (17)$$

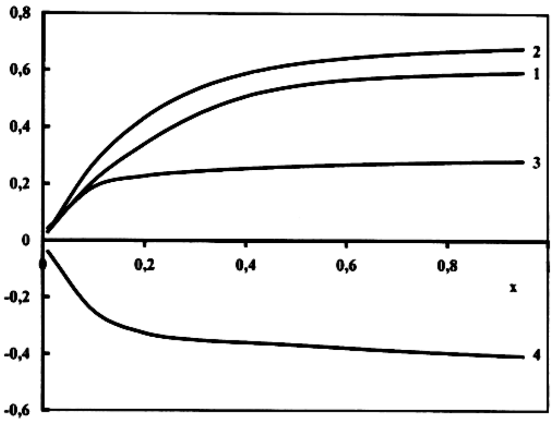

*Fig. 2.*Dependence of the left-right asymmetries $A(e_L^- - e_R^+)$, $A(e_R^- - e_L^+)$, $A^{(-)}(e_L^- - e_R^-)$, $A^{(+)}(e_L^+ - e_R^+)$ y=0,7.

4. The expressions of observed values have the phenomenological parameters that are quark and antiquark distribution functions in the polarized nucleons, values of which are defined by the experiment. In references [10-14] there are the assembages of quark distribution functions in adrons. For numerical estimates of the electroweak asymmetries we used the distribution functions of the valence and sea polarized quarks (antiquark) in nucleons given in [14].

We presented the numerical calculations of electroweak asymmetries (10)-(16) in the case of π - mezon electrocreation $e^{\mp}p\to e^{\mp}\pi X$ at $\sqrt{s}=300$ Gev (*ep*-collider HERA), x_w=0.232. The quark fragmentation function in π mezon is parametrized in the form $D_q^{\pi}(z)=N\dfrac{(1-z)^n}{z}$, where N and n are constant. It is supposed that strange quark and antiquark part in the fragmentation process in π- mezons is a small one. In dependences of left-right asymmetries $A(e_L^- - e_R^+)$, $A(e_R^- - e_L^+)$, $A^{(-)}(e_L^- - e_R^-)$,

$A^{(+)}(e_L^+ - e_R^+)$ and the charge asymmetries C_{RR}, C_{LL}, C_{RL}, C_{LR} on a variable x at the fixed value y=0,7 is given on the figures 2 and 3. As it is seen, the left-right asymmetries $A(e_L^- - e_R^+)$, $A(e_R^- - e_L^+)$, $A^{(-)}(e_L^- - e_R^-)$ and the charge asymmetries C_{RR}, C_{LL} increase monotonously with increase of X, and the asymmetries $A^{(+)}(e_L^+ - e_R^+)$, C_{RL} and C_{LR} decrease monotonously.

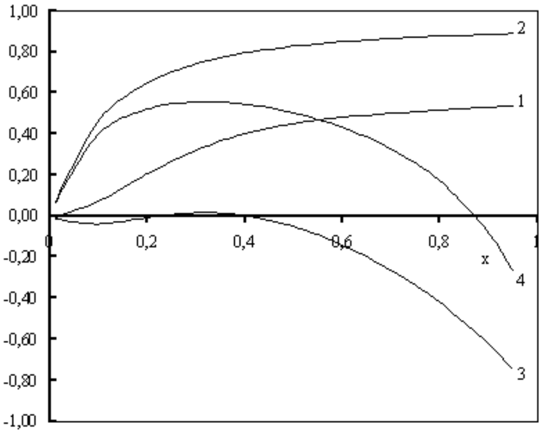

Fig. 3. Dependence of charging asymmetries C_{RR}, C_{LL}, C_{RL}, C_{LR} (curves 1, 2, 3 and 4 accordingly) from variable x at y=0,7.

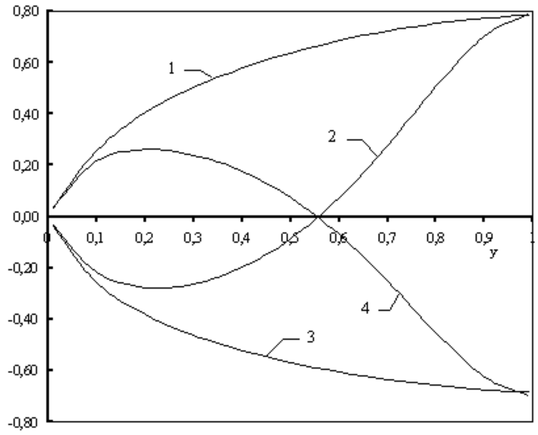

Fig.4. Dependence of charge-polarizing asymmetries $B_p^{(-)}$, $B_a^{(-)}$, $B_p^{(+)}$ and $B_a^{(+)}$ (curves 1, 2, 3 and 4 correspondingly) on variable y at x=0,5.

The analogous behaviour of asymmetries is observed for its y-dependences at fixed x (see fig. 4), where the dependence of charge-polarization asymmetries $B_p^{(\mp)}$ and $B_a^{(\mp)}$ on y at x=0.5 is presented.

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YARIMİNKLYUZİV $l^{\mp}N \to l^{\mp}hX$ PROSESLƏRİNDƏ ZƏİF NEYTRAL CƏRƏYAN EFFEKTLƏRİ

Standart və kvant-parton modelləri çərçivəsində polyarizə olunmuş elektronların polyarizə olunmuş nuklonlardan dərin qeyri-elastiki səpilmə proseslərində elektrozəif asimmetriyalar tədqiq edilmişdir. Sağ-sol, polyarizasiya, yük və yük-polyarizasiya asimmetriyaları üçün ifadələr alınmışdır.

С.К. Абдуллаев, А.И. Мухтаров, М.Ш. Годжаев

ЭФФЕКТЫ СЛАБЫХ НЕЙТРАЛЬНЫХ ТОКОВ В ПОЛУИНКЛЮЗИВНЫХ $l^{\mp}N \to l^{\mp}hX$ РЕАКЦИЯХ

В рамках стандартной теории и кварк-партонной модели проведено исследование электрослабых асимметрий в глубоконеупругом рассеянии поляризованных лептонов на поляризованных нуклонах. Получены выражения для лево-правых, поляризованных, зарядово-поляризационных и зарядовых асимметрий.

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