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LEPTON SCATTERING OFF POLARIZED PROTON TARGET AND NEUTRAL CURRENTS

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LEPTON SCATTERING OFF POLARIZED PROTON TARGET AND NEUTRAL CURRENTS

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Рассеяние лептонов на поляризованной протонной мишени и нейтральные токи

В модели Вайнберга вычисляется P-нечетная асимметрия, возникающая при рассеянии неполяризованных лептонов и антилептонов на поляризованной протонной мишени. Детально рассмотрены упругое и глубоко неупругое лептон-протонное рассеяние. Продольная асимметрия вычисляется в широком интервале углов и энергий и при различных значениях параметра Вайнберга $\sin^2\theta_W$.

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Bilenky S.M., Dadajan N.A., Hristova E.H. **E2 - 8196**

Lepton Scattering off Polarized Proton Target and Neutral Currents

The P-violating asymmetry of the scattering unpolarized leptons and antileptons off polarized proton target in the Weinberg model is calculated. The elastic and deep inelastic lepton-proton scattering are discussed in detail. The asymmetries in the different kinematical intervals are examined for different values of the Weinberg parameter $\sin^2\theta_W$.

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I. Introduction

In recent high energy neutrino experiments muonless events have been observed [1,2] which are most probably interpretable as processes caused by neutral currents. As is well known, neutral currents appear in the gauge theories of weak and electromagnetic interactions. The first experiments are in qualitative agreement with the predictions of the Weinberg model [3]. A further search for the effects which are due to neutral currents is exceptionally important for the theory.

In a large class of unified theories of weak and electromagnetic interactions a weak coupling of the charged leptons and the neutral hadron current arises.

Such an interaction would lead to P-violating effects in the various lepton-hadron processes: high energy lepton-nucleon scattering [4-8], atomic processes [9-10] and others.

In this paper we consider the effects of parity violation of the processes of lepton and antilepton scattering off polarized proton target in the framework of the Weinberg model. In section II the general structure of the cross section is discussed. In section III the elastic $e-p$ scattering when the target is polarized is considered. In section IV deep inelastic $e-p$ scattering with polarized target is discussed in the parton model.

II. Structure of the Cross Section

Let us consider lepton (antilepton) scattering off the polarized proton target. In the Weinberg theory the lepton is supposed to couple to the field of the massive neutral vector bosons Z_α and the interaction is of the form [2]

$$\mathcal{L} = i\frac{1}{2}\sqrt{g^2 + g'^2}\ (\bar{\ell}\gamma_\alpha(c_V + c_A\gamma_5)\ell)\ Z_\alpha . \quad (1)$$

Here

$$c_V = -\frac{1}{2} + 2\sin^2\theta_W ,$$
$$c_A = -\frac{1}{2}, \quad (2)$$

g and g' are the constants of the Weinberg theory. The weak coupling constant G equals

$$\frac{G}{\sqrt{2}} = \frac{g^2 + g'^2}{8 m_Z^2}, \quad (3)$$

where m_Z is the mass of the Z boson. In the simplest variant of the Weinberg theory the interaction of the field Z_α with the hadrons is [2].

$$\mathcal{L} = i\frac{1}{2}\sqrt{g^2 + g'^2}\ j_\alpha^Z\ Z_\alpha, \quad (4)$$

where the hadronic neutral current has the structure:

$$j_\alpha^Z = j_\alpha^3 - 2\sin^2\theta_W\ j_\alpha^{em} , \quad (5)$$

j_α^{em} is the electromagnetic hadronic current, j_α^3 is the third component of the strangeness conserving V–A weak current j_α^i .

We note that CERN data [1] are consistent with the assumption that neutral current has the form (5). Consider the process

$$\ell + p \to \ell + \dots \quad (6)$$

with unpolarized lepton beam and polarized proton target. The matrix element equals then (one proton approximation and the lowest order in G)

$$\langle f|S|i\rangle = i\frac{1}{(2\pi)^3}\left(\frac{m^2}{k_0 k_0'}\right)^{1/2}\frac{e^2}{q^2}[\bar{u}(k')\gamma_\alpha u(k)\langle p'|J_\alpha^{em}|p\rangle +$$
$$+ \rho\bar{u}(k')\gamma_\alpha(c_V + c_A\gamma_5)u(k)\langle p'|J_\alpha^Z|p\rangle](2\pi)^4\delta(p'-p-q) . \quad (7)$$

Here k and k' are the momenta of the initial and final leptons, p and p' are the initial and final momenta of the hadrons, $q = k - k'$, and

$$\rho = -\frac{G}{\sqrt{2}}\frac{m_Z^2}{q^2 + m_Z^2}\frac{q^2}{2\pi\alpha} ,$$
$$\alpha = \frac{e^2}{4\pi} \approx \frac{1}{137} . \quad (8)$$

We obtain then the following expression for the cross section of the process (6) (only the linear in the small parameter ρ terms were retained):

$$d\sigma = \frac{1}{(2\pi)^2}\frac{M}{|pk|}\frac{1}{2}\frac{e^4}{q^4}[L_{\alpha\beta}W_{\alpha\beta}^{em} + \rho(c_V L_{\alpha\beta} +$$
$$+ c_A e_{\alpha\beta\mu\nu}\ k_\mu k_\nu'\ W_{\alpha\beta}^I]\frac{d\vec{k}'}{k_0'} . \quad (9)$$

Here M is the mass of the proton

$$L_{\alpha\beta} = k_\alpha k_\beta' + \frac{1}{2}\delta_{\alpha\beta}q^2 + k_\alpha' k_\beta , \quad (10)$$

$$\int\Sigma\langle p'|J_\alpha^{em}|p\rangle\langle p|J_\beta^{em}|p'\rangle\delta(p'-p-q)\,d\Gamma = -\frac{1}{(2\pi)^6}\frac{M}{p_0}W_{\alpha\beta}^{em} , \quad (11)$$

$$\int\Sigma[\langle p'|J_\alpha^{em}|p\rangle\langle p|J_\beta^Z|p'\rangle + \langle p'|J_\alpha^Z|p\rangle\langle p|J_\beta^{em}|p'\rangle]\times$$
$$\times\delta(p'-p-q)\,d\Gamma = -\frac{1}{(2\pi)^6}\frac{M}{p_0}W_{\alpha\beta}^I . \quad (12)$$

The cross section for the process

$$\bar{\ell} + p \to \bar{\ell} + \dots \quad (13)$$

can be obtained from (10) replacing $c_A \to -c_A$.

Let us write the current J^z_α in the form

$$J^z_\alpha = V_\alpha + A_\alpha , \tag{14}$$

where

$$V_\alpha = V^3_\alpha - 2\sin^2\theta_W J^{em}_\alpha ,$$

$$A_\alpha = A^3_\alpha . \tag{15}$$

So we have

$$W^I_{\alpha\beta} = W^V_{\alpha\beta} + W^A_{\alpha\beta} . \tag{16}$$

If the initial proton is polarized

$$W^V_{\alpha\beta} = (W^V_{\alpha\beta})_0 + W^V_{\alpha\beta\sigma}\,\xi_\sigma ,$$

$$W^A_{\alpha\beta} = (W^A_{\alpha\beta})_0 + W^A_{\alpha\beta\sigma}\,\xi_\sigma , \tag{17}$$

where ξ_σ is four vector of the proton polarization. From PT -invariance of the strong interactions we obtain

$$(W^V_{\alpha\beta})_0 = (W^V_{\beta\alpha})_0$$

$$W^V_{\alpha\beta\sigma} = - W^V_{\beta\alpha\sigma}$$

$$(W^A_{\alpha\beta})_0 = -(W^A_{\beta\alpha})_0$$

$$W^A_{\alpha\beta\sigma} = W^A_{\beta\alpha\sigma} . \tag{18}$$

Hence for the cross section of the process (6) we obtain

$$d\sigma = \frac{2\alpha^2}{q^4}\,\frac{M}{|pk|}\,\frac{d\vec{k}'}{k'_0}\,[\, L_{\alpha\beta}W^{em}_{\alpha\beta} + \rho c_V\, L_{\alpha\beta}\,(W^V_{\alpha\beta})_0 +$$
$$+ \rho c_A\, e_{\alpha\beta\mu\nu}\, k_\mu k'_\nu (W^A_{\alpha\beta})_0 + \rho c_V L_{\alpha\beta} W^A_{\alpha\beta\sigma}\,\xi_\sigma +$$
$$+ \rho c_A\, e_{\alpha\beta\mu\nu}\, k_\mu k'_\nu\, W^V_{\alpha\beta\sigma}\,\xi_\sigma \,] . \tag{19}$$

The quantity $W^V_{\alpha\beta\sigma}$ is a pseudotensor of a third rank and it has the following general structure

$$W^V_{\alpha\beta\sigma} = \frac{1}{M} e_{\alpha\beta\mu\sigma}\, q_\mu X^V_1 + \frac{1}{M^3}(p_\alpha e_{\beta\mu\nu\sigma}\, q_\mu p_\nu \xi_\sigma -$$
$$- p_\beta e_{\alpha\mu\nu\sigma}\, q_\mu p_\nu \xi_\sigma) X^V_2 . \tag{20}$$

Omitting the terms proportional to q_α and q_β which do not contribute to the cross section we obtain

$$W^A_{\alpha\beta\sigma} = [\,\frac{1}{M}\delta_{\alpha\beta} X^A_1 + \frac{1}{M^3} p_\alpha p_\beta X^A_2\,] q_\sigma +$$
$$+ \frac{1}{M}(\delta_{\alpha\sigma} p_\beta + \delta_{\beta\sigma} p_\alpha) X^A_3 \tag{21}$$

and

$$W^{em}_{\alpha\beta} = \delta_{\alpha\beta} W^{em}_1 + \frac{1}{M^2} p_\alpha p_\beta W^{em}_2$$

$$(W^V_{\alpha\beta})_0 = \delta_{\alpha\beta} W^V_1 + \frac{1}{M^2} p_\alpha p_\beta W^V_2$$

$$(W^A_{\alpha\beta})_0 = \frac{1}{2M^2} e_{\alpha\beta\mu\nu}\, q_\mu p_\nu W^A_3 , \tag{22}$$

In these expressions X_1, X_2 and X_3 are real functions of q^2 and ν .

III. Elastic Scattering Off Polarized Target

In this section we consider the elastic scattering of unpolarized leptons (antileptons) off polarized proton target in the Weinberg model*. Using the transformation

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*Previously /11/ parity violating effects in the elastic lepton-proton scattering have been considered in the renormalizable weak interaction theory of Tanikawa-Watanaba /12/.

properties of the current J^i_α it is easy to show [3] that the matrix element $\langle p'|J^Z_\alpha|p\rangle$ is characterized by the electromagnetic and axial formfactors of the nucleon. We have

$$\langle p'|J^Z_\alpha|p\rangle = \frac{1}{(2\pi)^3}\left(\frac{M^2}{p_0 p'_0}\right)^{1/2} \bar{u}(p')\,[\,g^0_V \gamma_\alpha + $$

$$+ i(p+p')_\alpha f^0_V + g^0_A \gamma_\alpha \gamma_5 + i h^0_A (p-p')_\alpha \gamma_5\,]\, u(p)\,, \qquad (23)$$

where

$$g^0_V = G^V_M - 2\sin^2\theta_W\, G^p_M, \qquad G^V_M = \frac{1}{2}(G^p_M - G^n_M)$$

$$f^0_V = F^V - 2\sin^2\theta_W\, F^p, \qquad F^V = \frac{1}{2}(F^p - F^n)$$

$$g^0_A = \frac{1}{2} g_A\,, \qquad h^0_A = \frac{1}{2} h_A\,. \qquad (24)$$

In these expressions $F = \frac{F_2}{2M} = \frac{G_M - G_E}{2M\left(1+\frac{q^2}{4M^2}\right)}$ (G_M and G_E are the magnetic and charge formfactors). The formfactors g_A and h_A are defined as follows:

$$_p\langle p'|A^{1+i2}_\alpha|p\rangle_n = \frac{1}{(2\pi)^3}\left(\frac{M^2}{p_0 p'_0}\right)^{1/2} \bar{u}(p') \times$$

$$\times [g_A \gamma_\alpha \gamma_5 + i h_A (p-p')_\alpha]\, u(p)\,. \qquad (25)$$

Information about these formfactors may be extracted from data of the processes:

$$\nu_\mu + n \to \mu^- + p$$

$$\nu_\mu + p \to \mu^+ + n\,. \qquad (26)$$

Note that the formfactor h^0_A does not contribute to the cross section.

Calculating the nucleon traces we obtain the following expressions for the structure functions:

$$W^{em}_1 = \frac{q^2}{4M^2}(G^p_M)^2\, \delta\left(\nu - \frac{q^2}{4M}\right)$$

$$W^{em} = \frac{\frac{q^2}{4M^2}(G^p_M)^2 + (G^p_E)^2}{1+\frac{q^2}{4M^2}}\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$W^V_1 = \frac{q^2}{2M^2}[\,G^p_M G^V_M - 2\sin^2\theta_W (G^p_M)^2\,]\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$W^V_2 = \frac{2}{\left(1+\frac{q^2}{4M^2}\right)}\left[\left(\frac{q^2}{4M^2} G^p_M G^V_M + G^p_E G^V_E\right) - \right.$$

$$\left. - 2\sin^2\theta_W \left(\frac{q^2}{4M^2}(G^p_M)^2 + (G^p_E)^2\right)\right] \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$X^V_1 = G^p_M g^0_V\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$X^V_2 = M(G^p_M f^0_V + F^p g^0_V)\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$W^A_3 = -2 G^p_M g^0_A\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$X^A_1 = G^p_M g^0_A\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$X^A_2 = 2F^p g^0_A M\, \delta\left(\nu - \frac{q^2}{2M}\right)$$

$$X^A_3 = -G^p_E g^0_A\, \delta\left(\nu - \frac{q^2}{2M}\right)\,. \qquad (27)$$

In our case of parity violation the cross section of the scattering of unpolarized leptons off the target with polarization ξ_μ can be written as

$$d\sigma = d\sigma_0 \left(1 + A_1(\xi k) + A_2(\xi k')\right). \qquad (28)$$

In the laboratory frame, where

$$\xi = (\vec{p}, i0), \qquad (29)$$

the differential cross section takes the form

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_0 (1 + \vec{A}\vec{P}). \qquad (30)$$

For the vector $\bar{A}$, which lies in the scattering plane, we can write

$$\vec{A} = A_\kappa \vec{\kappa} + A_s \vec{s}. \qquad (31)$$

Here

$$\vec{\kappa} = \frac{\vec{k}}{|\vec{k}|} \qquad (32)$$

and $\bar{s}$ is a unit vector in the scattering plane perpendicular to $\vec{\kappa}$

$$\vec{s} = \vec{n} \times \vec{\kappa}, \quad \vec{n} = \frac{\vec{k} \times \vec{k}'}{|\vec{k} \times \vec{k}'|}. \qquad (33)$$

Thus, from (19)-(22) and (29) we obtain the following expressions (in the lab. frame) for the unpolarized cross section

$$\left(\frac{d\sigma}{d\Omega}\right)_0 = \left(\frac{d\sigma}{d\Omega}\right)_M \Bigg[(1 - 4\sin^2\theta_W \rho c_V) \Bigg(\frac{\frac{q^2}{4M^2}(G_M^p)^2 + (G_E^p)^2}{1 + \frac{q^2}{4M^2}} + 2\,\mathrm{tg}^2\frac{\theta}{2}\frac{q^2}{4M^2}(G_M^p)^2 \Bigg) + 2 c_V \rho \Bigg(\frac{\frac{q^2}{4M^2} G_M^p G_M^V + G_E^p G_E^V}{1 + \frac{q^2}{4M^2}}$$

$$+ 2\,\mathrm{tg}^2\frac{\theta}{2}\frac{q^2}{4M^2} G_M^p G_M^V \Bigg) \pm 2\rho c_A \mathrm{tg}^2\frac{\theta}{2} \frac{k_0 + k_0'}{M} G_M g_A^0$$

$$\left(\frac{d\sigma}{d\Omega}\right)_M = \frac{\alpha^2 \cos^2\frac{\theta}{2}}{4k_0^2 \sin^4\frac{\theta}{2}\left(1 + \frac{2k_0}{M}\sin^2\frac{\theta}{2}\right)}, \qquad (34)$$

where θ is the scattering angle in the laboratory frame.

The longitudinal asymmetry A_κ is

$$A_\kappa = 2\rho \frac{1}{B}\left(\frac{q^2}{2Mk_0}\right)\Big\{ c_V g_A^0 \Big[\left(G_M^p \mathrm{tg}^2\frac{\theta}{2} + MF^p\right)\left(1 + \frac{k_0}{M}\right) + \frac{2Mk_0}{q^2} G_E^p \Big] \pm c_A \Big[G_M^p g_V^0 \left(1 + \frac{k_0}{M}\mathrm{tg}^2\frac{\theta}{2}\right) - (G_M^p f_V^0 + F^p g_V^0) M \Big]\Big\}. \qquad (35)$$

$$B = \frac{\frac{q^2}{4M^2}(G_M^p)^2 + (G_E^p)^2}{1 + \frac{q^2}{4M^2}} + 2\,\mathrm{tg}^2\frac{\theta}{2}\frac{q^2}{4M^2}(G_M^p)^2. \qquad (36)$$

The perpendicular (in the scattering plane) asymmetry A_s equals

$$A_s = 2\rho \frac{1}{B}\left(\frac{q^2}{2Mk_0}\right)\Big\{ -c_V g_A^0 \Big[\mathrm{tg}\frac{\theta}{2}\left(G_M^p - \frac{2Mk_0}{q^2} G_E^p\right) + MF^p \mathrm{ctg}\frac{\theta}{2} \Big] \pm c_A \mathrm{tg}\frac{\theta}{2} \Big[G_M^p g_V^0 - (G_M^p f_V^0 + F^p g_V^0) M\left(1 + \frac{k_0}{M}\right) \Big]\Big\}. \qquad (37)$$

Let us discuss the obtained results. Supposing that $m_Z^2 \gg q^2$ the parameter ρ is

$$\rho = -1{,}55 \times 10^{-4} \frac{q^2}{M^2}. \qquad (38)$$

The small coefficient in front of the term $\frac{q^2}{M^2}$ causes smallness of the discussed effects. In order to obtain an asymmetry of about several percents we need large ($>100\ (\mathrm{GeV})^2$) momentum transfers. The q^2-dependence of the formfactors of the nucleon at such is unknown yet. We shall estimate the P-violation effects assuming the so-called scaling law:

$$\frac{1}{\mu_p} G_M^p(q^2) = \frac{1}{\mu_n} G_M^n(q^2) = G_E^p(q^2)$$

$$G_E^n(q^2) = 0 , \qquad (39)$$

where μ_p and μ_n are the magnetic momenta of the proton and neutron. Further on, we shall assume that the electromagnetic and axial formfactors of nucleon have the same q^2 dependence. Using the data available for $q^2 \gg M^2$ we can write /13, 14/.

$$\frac{1}{\mu_p} G_M^p(q^2) = \frac{0,40}{q^4} , \qquad g_A(q^2) = \frac{1,02}{q^4} . \qquad (40)$$

We have used these expressions to calculate the asymmetry. In the table we present the values of the longitudinal asymmetry for the scattering of leptons ($A_K(\ell)$) and antileptons ($A_K(\bar{\ell})$) off polarized proton target, which are calculated for the following values of $\sin^2\theta_W$: 0.1; 0.34; 0.4; 0.6.

We have taken the energies of the initial leptons equal: 100, 200, 300 GeV in the interval of the angles of the final lepton: 10°- 40°. As it is apparent from the table the longitudinal asymmetry $A_K(\ell)$ strongly depends on the Weinberg parameter $\sin^2\theta_W$. If $\sin^2\theta_W = 0.34$, the asymmetry is less than 0.1%. If $\sin^2\theta_W = 0.4$ it reaches 2.2%. The asymmetry $A_K(\bar{\ell})$ which arises in the antilepton scattering off polarized proton target not so strongly depends on the Weinberg parameter $\sin^2\theta_W$.

From the CERN data on neutral currents /15/ it follows that $\sin^2\theta_W = 0.34 \pm 0.05$.

From the experiment on searching $\bar{\nu}_\mu + e \to \bar{\nu}_\mu + e$ was found /16/ $0.1 < \sin^2\theta_W < 0.6$.

The perpendicular asymmetry A_s (if eq. (3.9)

Table I

K (GeV)	θ°	$\sin^2\theta_W = 0.1$ $A_K(\ell)$	$\sin^2\theta_W = 0.1$ $A_K(\bar{\ell})$	$\sin^2\theta_W = 0.34$ $A_K(\ell)$	$\sin^2\theta_W = 0.34$ $A_K(\bar{\ell})$	$\sin^2\theta_W = 0.4$ $A_K(\ell)$	$\sin^2\theta_W = 0.4$ $A_K(\bar{\ell})$	$\sin^2\theta_W = 0.6$ $A_K(\ell)$	$\sin^2\theta_W = 0.6$ $A_K(\bar{\ell})$
100	10	1.50	-0.41	-0.09	-0.58	-0.49	-0.62	-1.82	-0.76
	20	2.47	-0.96	-0.03	-0.92	-0.66	-0.91	-2.72	-0.85
	30	2.71	-1.09	-0.02	-0.91	-0.71	-0.98	-2.96	-0.89
	40	2.79	-1.13	-0.02	-1.04	-0.73	-1.01	-3.05	-0.91
200	10	4.08	-1.49	-0.10	-1.58	-1.17	-1.60	-4.60	-1.60
	20	5.24	-2.18	-0.03	-2.04	-1.38	-1.98	-5.71	-1.75
	30	5.48	-2.30	-0.09	-2.13	-1.44	-2.07	-5.95	-1.81
	40	5.56	-2.34	-0.03	-2.16	-1.46	-2.10	-6.03	-1.83
	10	6.71	-2.69	-0.1	-2.69	-1.85	-2.66	-7.40	-2.47
	20	7.89	-3.40	-0.04	-3.19	-2.09	-3.10	-8.54	-2.67
	30	8.11	-3.51	-0.04	-3.29	-2.15	-3.19	-8.76	-2.73
	40	8.19	-3.55	-0.03	-3.33	-2.17	-3.22	-8.85	-2.75

The longitudinal asymmetry (in percents) arising in the elastic lepton ($A_K(\ell)$) and antilepton ($A_K(\bar{\ell})$) scattering off the polarized protons; K_o is the laboratory energy of the incoming leptons, θ° is the scattering angle in the lab.frame and $\sin^2\theta_W$ is the Weinberg parameter.

takes place) is essentially smaller than longitudinal asymmetry $|A_\kappa|$

$A_s(\ell) = 0.003\%$ $\quad k_0 = 200$ GeV $\quad \sin^2\theta_W = 0.4.$

$A_\kappa(\ell) = -1.46\%.$

If we assume that magnetic and axial formfactors have the same behaviour at large q^2, then the multipliers, characterizing q^2 -dependence of the form factors would cancel in the expression of the asymmetry. The values

$(\frac{d\sigma}{d\Omega})_0$ depend strongly on the assumptions one makes for the q^2 behaviour of the formfactors. If formfactors continue to decrease as $\frac{1}{q^4}$ the cross section in the considered values of q^2 is proved to be highly small:

$(\frac{d\sigma}{d\Omega}) = 3.5\text{x}10^{-41}$ (sm)^2 for $k_0 =$ 200 GeV and $\sin^2\theta_W = 0,4.$

It is evident also, that the values of asymmetry depend on assumption about the q^2 dependence of the formfactors.

When this work was finished we learnt about paper [8], in which the longitudinal asymmetry in the elastic lepton-nucleon scattering with a polarized target had been calculated in the Weinberg model. The analytic expression for the $A_\kappa(\ell)$ eq. (35) coincides with the one, obtained in ref.[8]. Nevertheless, the numerical estimates differ because different assumptions were made about the q^2 - dependence of the electromagnetic formfactors.

IV. Deep Inelastic Lepton Scattering on a Polarized Proton Target

Let us consider the deep inelastic lepton scattering on a polarized proton target. If alongside with the electromagnetic interaction there exists the weak coupling [1,4] too, a P-violating asymmetry should appear. Here we shall consider the longitudinal asymmetry. The calculations will be performed in the quark parton model[18]. We shall use the following expression for the hadronic neutral current

$$j_\alpha^Z = \bar{p}\gamma_\alpha(g_V^{(1)} + g_A^{(1)}\gamma_5)p + \bar{n}\gamma_\alpha(g_V^{(2)} + g_A^{(2)}\gamma_5)n, \quad (41)$$

where p and n are quark fields with quantum numbers $S = 0$ and $I_3 = \frac{1}{2}$ and $-\frac{1}{2}$ respectively, and

$$g_V^{(1)} = \frac{1}{2} - \frac{4}{3}\sin^2\theta_W$$

$$g_A^{(1)} = \frac{1}{2}$$

$$g_V^{(2)} = -\frac{1}{2} + \frac{2}{3}\sin^2\theta_W$$

$$g_A^{(2)} = -\frac{1}{2}. \quad (42)$$

Let us consider the scattering off a proton with helicity $+1$. For $W^V_{\alpha\beta\sigma}$ and $W^A_{\alpha\beta\sigma}$ defined by eqs. (12), (16) and (17) we find:

$$W^V_{\alpha\beta\sigma} = \frac{1}{M\nu}G_1 e_{\alpha\beta\mu\sigma} q_\mu, \quad (43)$$

$$W^A_{\alpha\beta\sigma} = \frac{1}{M\nu}G_2[\delta_{\alpha\beta}q_\sigma - (p_\alpha\delta_{\beta\sigma} + p_\beta\delta_{\alpha\sigma})], \quad (44)$$

where

$$G_1(x) = \Sigma Q_i g_V^i(f_i^+(x) - f_i^-(x)), \quad (45)$$

$$G_2(x) = \Sigma Q_i g_A^i(f_i^+(x) - f_i^-(x))\eta_i. \quad (46)$$

In these expressions $f_i^+(x)$ ($f_i^-(x)$) are the numbers of the i -particle with helicity $+1$ (-1), the factor η_i equals 1 for the parton and -1 for the antiproton, $x = q^2/2M\nu$, Q_i is the charge of the i -th parton. The differential cross section for the considered process in the laboratory frame, if the proton polarization is

$$\xi = (p\vec{\kappa},\ i0) \quad (\vec{\kappa} = \frac{\vec{k}}{|\vec{k}|})$$

has the form

$$\frac{d^2\sigma}{d\Omega\, dk_0'} = (\frac{d^2\sigma}{d\Omega\, dk_0'})\quad (1 + A_{\vec{\kappa}} P)\,. \qquad (47)$$

Using eqs. (43) and (44) we obtain the following expression for the longitudinal asymmetry

$$A_\kappa = \frac{2\rho}{(\nu W_2)_{em}\ (1 + \frac{\nu}{Mx} tg^2 \frac{\theta}{2})} [\pm c_A G_1 tg^2 \frac{\theta}{2} \ \frac{k_0 + k_0' \cos\theta}{M} +$$

$$+ c_V G_2 (tg^2 \frac{\theta}{2}\ \frac{k_0 - k_0' \cos\theta}{M} + x)], \qquad (48)$$

where c_V, c_A and ρ are defined by (2) and (8) and the sign (+) or (-) refers to the lepton or the antilepton scattering respectively. In the parton model the structure function $(\nu W_2)_{em}$ equals

$$(\nu W_2)_{em} = \Sigma (f_i^+ + f_i^-)\, Q_i^2\, x\,. \qquad (49)$$

It is determined in the deep inelastic experiments with unpolarized leptons and hadrons.

We can obtain some information about the quantities $(f_i^+(x) - f_i^-(x))$ from the planned deep inelastic experiments with polarized lepton beams on a polarized target.

In order to estimate the P-violating asymmetry we shall use parton model of Kti-Weiskopf /19/. For the functions G_1 and G_2 we obtain

$$G_1(x) = (-\frac{7}{18} + \frac{10}{9}\sin^2\theta_W)\, G$$

$$G_2(x) = -\frac{7}{18} G\,, \qquad (50)$$

where

$$G = \frac{35}{32} x^{-1/2} (1-x)^3\,.$$

We shall use the following parametrization for

$$(\nu W_2)_{em} = \sum_{i=1}^{3} a_i (1-x)^{i+3}$$

$$a_1 = 1.12;\quad a_2 = 1.00\,;\quad a_3 = -1.98. \qquad (51)$$

which is consistent with the available data on deep inelastic e-p scattering.

In Figs. (1-4) the asymmetry A_κ in percents is plotted against k_0' for different values of the scattering angle θ (θ = 10, 20, 35) and at the energies of the incoming lepton (antilepton) equal 200, 300 GeV.* For the parameter $\sin^2\theta_W$ the following values have been taken:

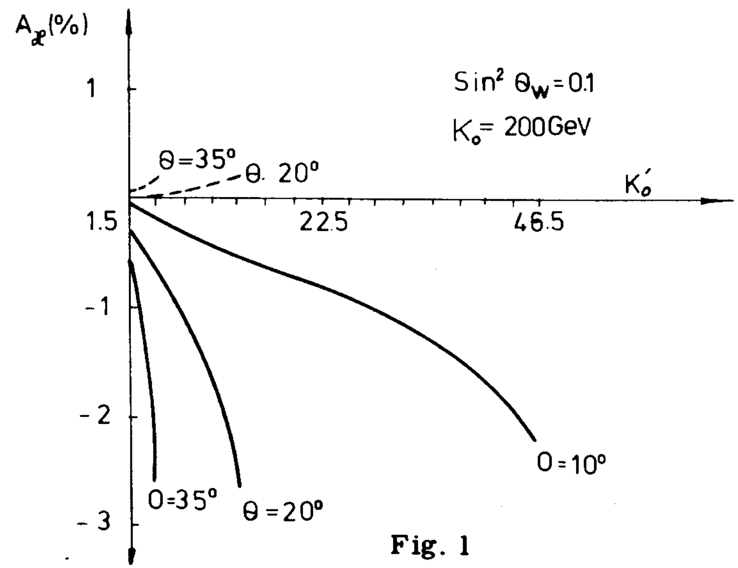

Fig. 1

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* The P-violating asymmetry have been calculated in ref. /7/ too, for $\sin^2\theta_W = 0$.

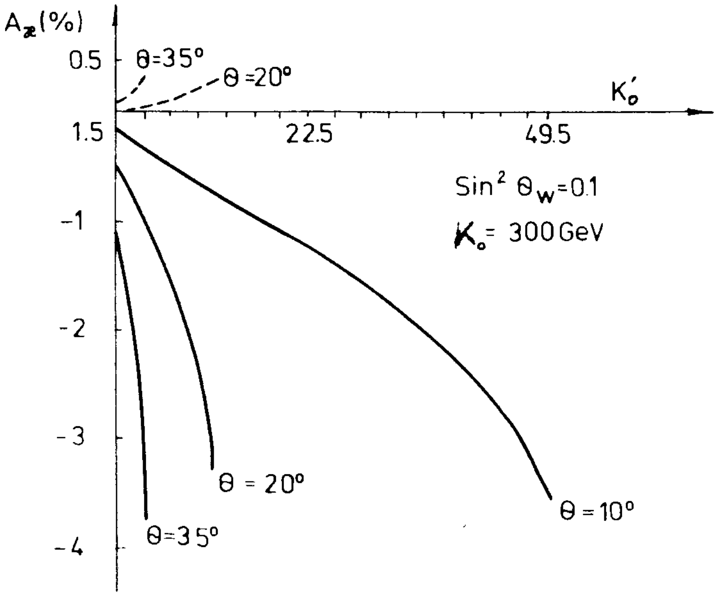

Fig. 2

0.1; 0.4; 0.6. The dashed line notes the asymmetry $A_\kappa(\bar{\ell})$ and the full line is the asymmetry $A_\kappa(\ell)$ .As is clear from the figures, $A_\kappa(\ell)$ is less than $|A_\kappa(\ell)|$. For $\sin^2\theta_W$ the asymmetry $A_\kappa(\bar{\ell})$ in the considered kinematical intervals is less than 0.3%. If $\sin^2\theta_W = 0.34$ the asymmetries $|A_\kappa(\ell)|$ and $A_\kappa(\bar{\ell})$ are approximately equal and do not surpass 1.2%.

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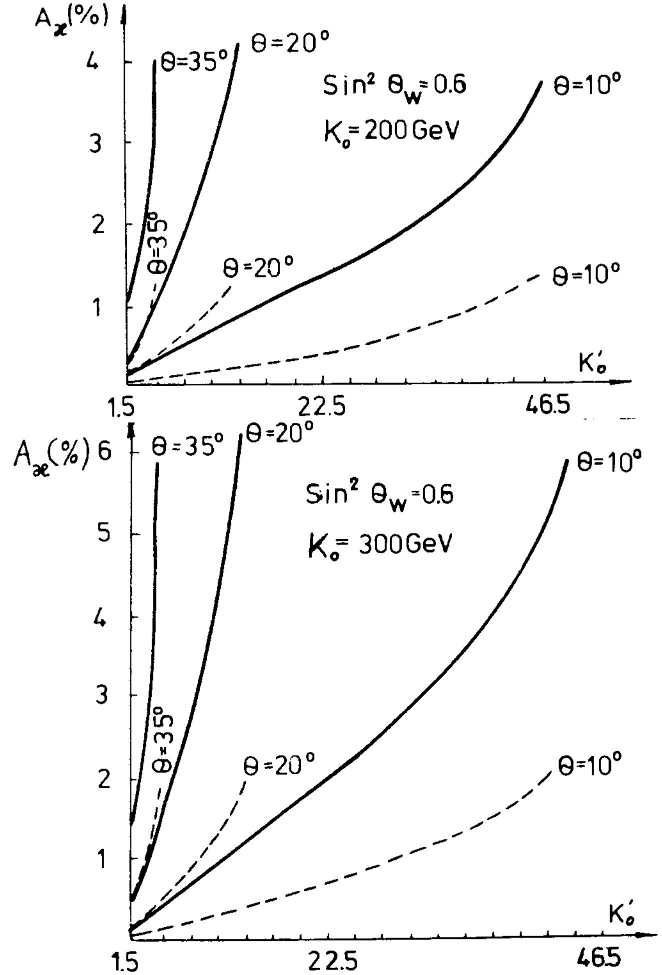

Fig. 3

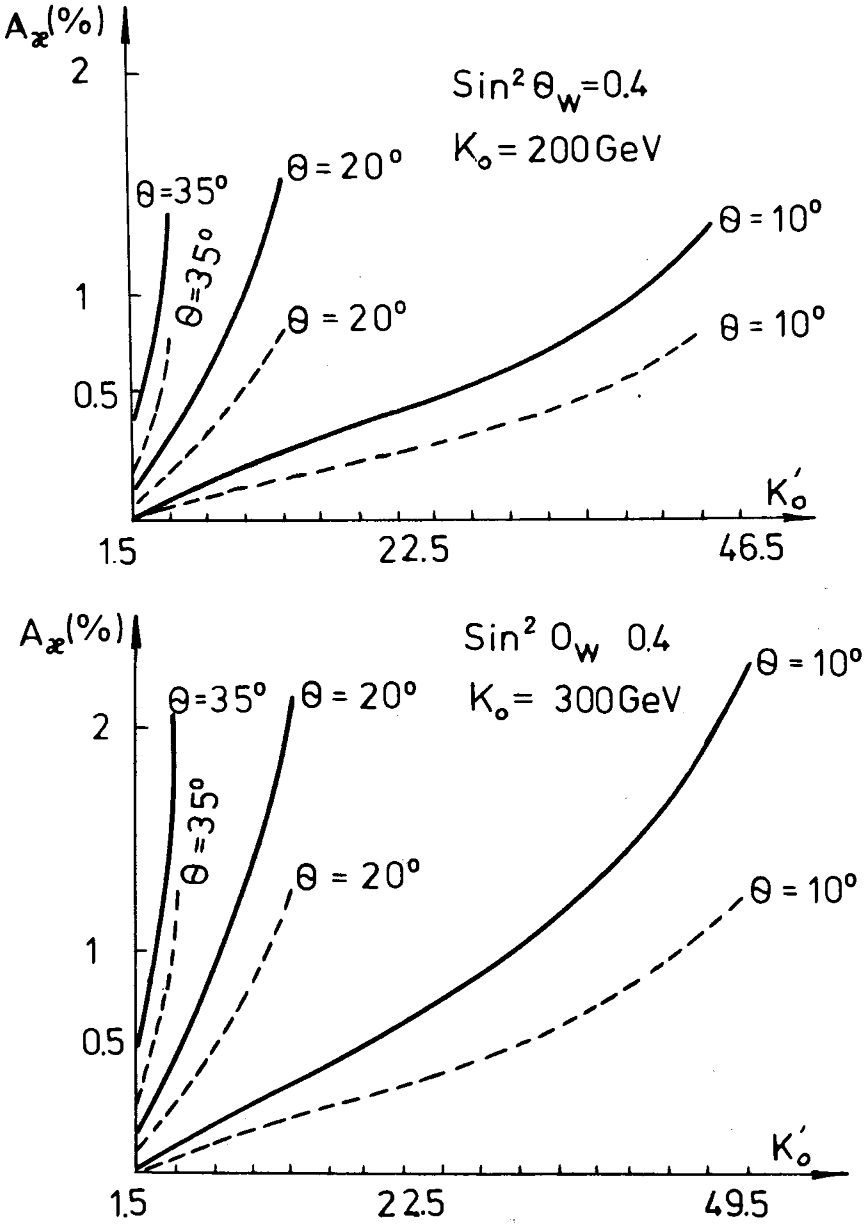

Fig. 4

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