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ON THE PARITY VIOLATION EFFECTS IN DEEP INELASTIC LEPTON-HADRON SCATTERING

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О P-нечётных эффектах в глубоко-неупругом рассеянии заряженных лептонов нуклонами

Дан обзор P-нечетных эффектов в глубоко-неупругом рассеянии поляризованных заряженных лептонов адронами, возникающих за счет интерференции слабой и электромагнитной амплитуд. Приводятся выражения для асимметрии в двух различных $SU(2) \times U(1)$ калибровочных схемах - в стандартной модели слабого взаимодействия и в модели, в которой нейтральный ток заряженных лептонов - вектор. Численные оценки возможных P-нечётных эффектов показывают, что при $q^2 \sim 100$ (ГэВ)^2 они могут составлять несколько процентов.

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Bilenky S.M., Petcov S.T. **E2 - 10809**

On the Parity Violation Effects in Deep Inelastic Lepton-Hadron Scattering

The parity violation effects in deep inelastic scattering of polarized leptons on nucleons arizing due to the interference of the electromagnetic and weak amplitudes are reviewed. A phenomenological discussion of the relevant asymmetries is given. The expressions for the asymmetries are obtained in the parton approximation. Numerical estimates are given in two different $SU(2) \times U(1)$ gauge models - in the standard one and in a vector-like extension of the standard model with pure vector neutral current of the charged leptons.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

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I. Introduction

The correctness of the general strategy of the gauge theories of weak and electromagnetic interactions has been remarkably confirmed by the spectacular discoveries of the neutral currents[1] and the charmed particles[2].

Further important test of these theories would be the discovery of a weak lepton-hadron as well as lepton-lepton interactions which naturally arise in the gauge schemes. There are many proposals to search for such an interactions in

I. deep inelastic lepton-nucleon scattering [3-6,24]

$$\ell^{\mp} + N \rightarrow \ell^{\mp} + X \qquad (\ell = e, \mu); \tag{I}$$

2. atomic transitions [7],
3. purely leptonic processes in e^+e^- collisions [8],
4. lepton-hadron processes in e^+e^- collisions [9].

The first experimental study of the reaction (I) with polarized muon [10] and electron[11] beams has set an upper bound of the parity violating asymmetry approximately by an order of magnitude greater than the value predicted by the theory (in the experiments [10,11] it was obtained : $G_0=(6\pm 10)G$ and $G_0 < 10G$, respectively; G_0 being the effective coupling constant of the parity-violating interaction)

Recently the first results of two experiments[12] on the possible parity violation effects in the atomic transitions in ^{209}Bi atoms have been published. They appear to indicate that the parity violation effects in heavy atoms are smaller than those predicted by the standard theory [13,14] of weak interactions.

The present short review is devoted to the discussion of the parity violation effects in deep inelastic scattering of polarized charged leptons on nucleons. The parity violation effects in these processes are due to the interference of the contributions of the diagrams with exchange of a photon and a Z^0-boson and they have an order of magnitude characterized by the parameter

$$\rho = \frac{G}{\sqrt{2}} \frac{q^2}{2\pi\alpha} \simeq 1{,}6 \cdot 10^{-4} \frac{q^2}{M^2}, \tag{2}$$

where M is the proton mass and q^2 is the square of the momentum transferred to the hadrons. At present an experiment on deep inelastic μ-N scattering is under preparation[15] at CERN SPS.

The expected range of values of q^2 to be reached in this experiment is $q^2 \lesssim 500(\mathrm{GeV})^2$. The parity violation effects can be of an order of a few per cent for $q^2 \gtrsim 100(\mathrm{GeV})^2$, thus being measurable in principle.

2. The general expression for the differential cross sections of the processes $\ell^{\mp} + N \to \ell^{\mp} + X$

The effective Hamiltonian of the weak interaction of charged leptons and hadrons can be written as

$$\mathcal{H} = \frac{G}{\sqrt{2}} 2 j_\alpha^{\ell} j_\alpha^{h} . \tag{3}$$

Here

$$j_\alpha^{\ell} = v_\alpha^{\ell} + a_\alpha^{\ell} = \bar{\ell}\gamma_\alpha(g_V + g_A\gamma_5)\ell \tag{4}$$

is the lepton neutral current and j_α^{h} is the weak hadron neutral (V, A) current. In terms of the quark fields one has*/:

$$j_\alpha^{h} = v_\alpha^{h} + a_\alpha^{h} = \sum_q \bar{q}\gamma_\alpha(v_q + a_q\gamma_5)q . \tag{5}$$

In the standard theory of weak interactions the constants g_V, g_A, v_q and a_q are given by the expressions:

$$\begin{aligned} g_V &= -\frac{1}{2} + 2\sin^2\theta_W , \quad g_A = -\frac{1}{2} , \\ v_u &= \frac{1}{2} - \frac{4}{3}\sin^2\theta_W , \quad a_u = \frac{1}{2} , \\ v_d &= -\frac{1}{2} + \frac{2}{3}\sin^2\theta_W , \quad a_d = -\frac{1}{2} , \end{aligned} \tag{6}$$

etc., where θ_W is the Weinberg angle.

The relevant diagrams for the processes(I) are shown in Fig.I. The corresponding matrix elements have the form:

$$\langle f|S|i\rangle_{\ell^{\mp}} = \pm i N_s \frac{e^2}{q^2}\Big[\bar{u}(k')\gamma_\alpha u(k)\langle p'|J_\alpha^{em}|p\rangle - $$
$$- \rho\, \bar{u}(k')\gamma_\alpha(g_V \pm g_A\gamma_5)u(k)\langle p'|J_\alpha^{h}|p\rangle\Big](2\pi)^4\delta(p'-p-q). \tag{7}$$

Here J_α^{em} and J_α^{h} are the electromagnetic and weak neutral hadron currents respectively, N_s is a standard normalization factor, k and k' are the momenta of the initial and final leptons, p is the momentum of the initial nucleon, p' is the total momentum of the final hadrons, and the parameter ρ is defined by the equation(2).

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*/ Note that only the diagonal terms of the weak neutral hadron current can contribute to the interference of the weak and electromagnetic amplitudes which is discussed here.

Note that the matrix element for ℓ^+-scattering can be obtained from that one for ℓ^--scattering replacing $g_A \to -g_A$.

Using the eq.(7) and keeping only the contributions of the diagram in Fig.Ia and the interference of the diagrams in Fig.Ia and Fig.Ib, we can write the cross sections of the processes(I) as

$$\left(\frac{d^2\sigma_{\mp}}{dq^2 d\nu}\right)_\lambda = \left(\frac{d^2\sigma}{dq^2 d\nu}\right)_{em} \left\{ 1 + \rho\left[(-g_V\alpha_V \mp g_A\alpha_A) + \lambda(g_V\alpha_A \pm g_A\alpha_V)\right]\right\} \quad (8)$$

Here $\left(\frac{d^2\sigma}{dq^2 d\nu}\right)_{em}$ is the cross section of the processes (I) in the one-photon approximation, $\nu = -\frac{pq}{M}$, λ is the longitudinal polarization of the incoming leptons, and α_V and α_A are defined as

$$\alpha_V = \frac{L_{\alpha\beta}(\kappa,\kappa')W^I_{\alpha\beta}}{L_{\alpha\beta}(\kappa,\kappa')W^{em}_{\alpha\beta}}, \quad \alpha_A = \frac{e_{\alpha\beta\rho\sigma}\kappa_\rho\kappa'_\sigma W^I_{\alpha\beta}}{L_{\alpha\beta}(\kappa,\kappa')W^{em}_{\alpha\beta}}, \quad (9)$$

where

$$L_{\alpha\beta}(\kappa,\kappa') = \kappa_\alpha\kappa'_\beta - \delta_{\alpha\beta}(\kappa\kappa') + \kappa_\beta\kappa'_\alpha, \quad (10)$$

and

$$W^{em}_{\alpha\beta} = -(2\pi)^6\frac{p_0}{M}\sum\int \langle p'|J^{em}_\alpha|p\rangle\langle p|J^{em}_\beta|p'\rangle\delta(p'-p-q)d\Gamma \quad (11)$$

$$W^I_{\alpha\beta} = -(2\pi)^6\frac{p_0}{M}\sum\int\left[\langle p'|J^{em}_\alpha|p\rangle\langle p|J^h_\beta|p'\rangle + \langle p'|J^h_\alpha|p\rangle\langle p|J^{em}_\beta|p'\rangle\right]\delta(p'-p-q)d\Gamma \quad (12)$$

As is easily seen from eqs.(9)-(12), the symmetrical part of the tensor $W^I_{\alpha\beta}$ contributes to the quantity α_V while the antisymmetrical part of $W^I_{\alpha\beta}$ contributes respectively to α_A. So the contributions of vector and axial-vector parts of the weak hadronic current to the interference term in eq,(8) are characterized by α_V and α_A, respectively.

It is obvious that the first two terms in the square brackets in eq.(8) are due to the interference of the one photon matrix element and the matrix element of the parity conserving part of the Hamiltonian (3): $\mathcal{H}_{PC} = \frac{G}{\sqrt{2}}2(v^\ell_\alpha v^h_\alpha + a^\ell_\alpha a^h_\alpha)$ while the last two terms in the square brackets in (8) are due to the interference of the one-photon matrix element with the matrix element of the parity nonconserving part of the Hamiltonian (3):

$$\mathcal{H}_{PV} = \frac{G}{\sqrt{2}}2(v^\ell_\alpha a^h_\alpha + a^\ell_\alpha v^h_\alpha).$$

We are going to discuss the possible experiments which can give evidences for the existence of a weak interaction between charged leptons and hadrons. Consider firstly the experiments with leptons of a fixed charge designed to measure the dependence of the differential cross section of the process (I) on the longitudinal polarization λ . In such experiments the following **P**-odd asymmetry is measured:

$$A_{\mp} = \frac{\left(\frac{d^2\sigma_{\mp}}{dq^2 d\nu}\right)_{\lambda=1} - \left(\frac{d^2\sigma_{\mp}}{dq^2 d\nu}\right)_{\lambda=-1}}{\left(\frac{d^2\sigma_{\mp}}{dq^2 d\nu}\right)_{\lambda=1} + \left(\frac{d^2\sigma_{\mp}}{dq^2 d\nu}\right)_{\lambda=-1}} \quad . \tag{I3}$$

From (8) and (I5) it follows that

$$A_{\mp} = \rho(g_V \alpha_A \pm g_A \alpha_V) \tag{I4}$$

If the asymmetry A_- (or A_+) is different from zero then one should inevitably conclude that the parity-violating interaction between charged leptons and hadrons does exists. Note that in general $A_- \neq A_+$.

Let us proceed to the possible experiments on the determination of the difference between the cross sections of deep inelastic scattering of leptons with opposite charges on nucleons. First of all, it is clear that the interpretation of the results of such experiments requires a good deal of knowledge about the interference contribution of the one- and two-photon exchange diagrams to the relevant cross sections. We shall not discuss this problem here. It is worth-while to note only that the two-photon exchange contribution can be evaluated in the framework of the parton model [I6].

Consider now the asymmetry arising in the scattering of unpolarized leptons with opposite charges. Using the eq.(8) it is easy to obtain

$$C = \frac{\left(\frac{d^2\sigma_-}{dq^2 d\nu}\right)_{\lambda=0} - \left(\frac{d^2\sigma_+}{dq^2 d\nu}\right)_{\lambda=0}}{\left(\frac{d^2\sigma_-}{dq^2}\right)_{\lambda=0} + \left(\frac{d^2\sigma_+}{dq^2 d\nu}\right)_{\lambda=0}} = -\rho\alpha_A g_A \cdot \tag{I5}$$

If (after the two-photon exchange contribution is taken into account) the asymmetry C is found to be different from zero, then one can conclude only that there is a term

$$a_\alpha^\ell \cdot a_\alpha^h \tag{I6}$$

in the lepton-hadron interaction Hamiltonian. Certainly the measurement of the asymmetry C alone cannot give any information about the parity nonconservation.

We would like to make the following remark related to this discussion. Suppose that the weak interaction lepton-hadron effective Hamiltonian has the form

$$\mathcal{H} = g\frac{G}{\sqrt{2}}\{[\bar{\nu}_\mu\gamma_\alpha\nu_\mu + g_V'\bar{\mu}\gamma_\alpha\mu]v_\alpha^h + + [\bar{\nu}_\mu\gamma_\alpha\gamma_5\nu_\mu + g_A'\bar{\mu}\gamma_\alpha\gamma_5\mu]a_\alpha^h\} + (\mu\to e). \quad (17)$$

Such an interaction can arise in a gauge theory with two neutral intermediate bosons [17]. It is apparent that the Hamiltonian (17) conserves parity. The neutrinos originated in π- and K-decays are always left-handed. So when considering the neutrino-induced processes one should substitute $\nu_\mu\to\nu_{\mu L}$ ($\nu_{\mu L}=\frac{1}{2}(1+\gamma_5)\nu_\mu$) in the expression (17). Therefore the effective Hamiltonian for such a processes can be written in the form of [17,18]:

$$\mathcal{H} = \frac{G}{\sqrt{2}}(\bar{\nu}_\mu\gamma_\alpha(1+\gamma_5)\nu_\mu)\,(v_\alpha^h + a_\alpha^h). \quad (18)$$

In particular, from (18) it follows that $\sigma(\nu_\mu+N\to\nu_\mu+X)\neq\sigma(\bar{\nu}_\mu+N\to\bar{\nu}_\mu+X)$, which is in agreement with the neutrino experiment data [19-21]. Thus, if the asymmetry C turns out to be different from zero then even in the framework of gauge theories no unambiguous conclusions about the parity nonconservation in the weak interaction of the charged leptons and hadrons can be drawn despite the neutrino experiment data which show that cross sections of the processes $\nu_\mu+N\to\mu^-+X$ and $\bar{\nu}_\mu+N\to\mu^++X$ differ.

Consider further the asymmetry

$$B(\lambda)=\left[\left(\frac{d^2\sigma_-}{dq^2d\nu}\right)_\lambda-\left(\frac{d^2\sigma_+}{dq^2d\nu}\right)_{-\lambda}\right]\Big/\left[\left(\frac{d^2\sigma_-}{dq^2d\nu}\right)_\lambda+\left(\frac{d^2\sigma_+}{dq^2d\nu}\right)_{-\lambda}\right] \quad (19)$$

arising when the charge and the polarization of the lepton beam are changed simultaneously. Using the eq.(8) one can find that

$$B(\lambda)=\rho(-g_A+\lambda g_V)\alpha_A. \quad (20)$$

As is seen from eq.(20) the parity nonconserving term $v_\alpha^l a_\alpha^h$ of the Hamiltonian (3) as well as the term $a_\alpha^l a_\alpha^h$ which conserves parity contribute to the asymmetry $B(\lambda)$.

If the asymmetry $B(\lambda)$ proves to be different from zero it should undoubtly mean that $a_\alpha^h\neq 0$. The measurements of the asymmetry $B(\lambda)$ alone for a fixed values of the polarization λ can give no definite information about the parity nonconservation in the lepton-hadron interaction. However it is clear that when performing measurements of $B(\lambda)$ for different values of λ one can determine experimentally both $g_A\alpha_A$ and $g_V\alpha_A$ terms. Finally let us note that the asymmetries $B(\lambda)$ and C are related by the equation

$$C = \frac{g_A}{g_A - \lambda g_V} B(\lambda). \tag{21}$$

3. The structure functions. Parton approximation

It is well known that the tensor $W^{em}_{\alpha\beta}$ has the following structure

$$W^{em}_{\alpha\beta} = (\delta_{\alpha\beta} - \frac{q_\alpha q_\beta}{q^2}) W_1 + \frac{1}{M^2}(p_\alpha - \frac{pq}{q^2}q_\alpha)(p_\beta - \frac{pq}{q^2}q_\beta) W_2. \tag{22}$$

The tensor $W^I_{\alpha\beta}$ arising from the interference of the diagrams in Fig.Ia and Fig.Ib can be written in the following general form [3]:

$$W^I_{\alpha\beta} = (\delta_{\alpha\beta} - \frac{q_\alpha q_\beta}{q^2}) R_1 + \frac{1}{M^2}(p_\alpha - \frac{pq}{q^2}q_\alpha)(p_\beta - \frac{pq}{q^2}q_\beta) R_2 + \\ + \frac{1}{2M^2} \varepsilon_{\alpha\beta\rho\sigma} q_\rho p_\sigma R_3 , \tag{23}$$

where the structure functions R_i depend in general on q^2 and ν */. Using the eqs.(9),(22) and (23) we can express α_V and α_A in terms of the structure functions R_i and W_i :

$$\alpha_V = \frac{2q^2 R_1 + [4E(E-\nu) - q^2] R_2}{2q^2 W_1 + [4E(E-\nu) - q^2] W_2}, \tag{24}$$

$$\alpha_A = \frac{-q^2 \frac{2E-\nu}{M} R_3}{2q^2 W_1 + [4E(E-\nu) - q^2] W_2}, \tag{25}$$

E being the energy of the initial lepton.

Further one can easily obtain the expressions for the structure functions R_i in the quark-parton approximation. Using the eqs. (5) and (23) we have:

$$\begin{aligned} R_1 &= \frac{1}{M}\sum_q Q_q v_q (f_q(x) + f_{\bar q}(x)), \\ R_2 &= \frac{2x}{\nu}\sum_q Q_q v_q (f_q(x) + f_{\bar q}(x)), \\ R_3 &= -\frac{2}{\nu}\sum_q Q_q a_q (f_q(x) - f_{\bar q}(x)), \end{aligned} \tag{26}$$

where Q_q denotes the charge of q-quark ($q = u, d, s, ..$) and $f_q(x)$ ($f_{\bar q}(x)$) is the number of q-quarks ($\bar q$-antiquarks) with momentum xp in the nucleon ($x = -\frac{q^2}{2M\nu}$). So, in the parton model the structure functions R_i depend only on the scaling variable x, and the functions R_1 and R_2 are related by [3]

$$\nu R_2 = 2x M R_1 . \tag{27}$$

Finally from (24)-(26) we get:

$$\alpha_V = 2\frac{\sum_q Q_q v_q (f_q(x) + f_{\bar q}(x))}{\sum_q Q_q^2 (f_q(x) + f_{\bar q}(x))}, \tag{28}$$

*/ Note that the terms proportional to q have been omitted since they do not contribute to the cross sections.

$$\alpha_A = 2\frac{y(2-y)}{1+(1-y)^2}\frac{\sum_q a_q v_q (f_q(x)-f_{\bar q}(x))}{\sum_q a_q^2 (f_q(x)+f_{\bar q}(x))}, \qquad (29)$$

where $y = \frac{\nu}{E}$.

4. The asymmetries $A_\mp$, B and C in concrete gauge schemes

The parameters g_V, g_A, v_q and a_q cannot be determined unambiguosly from the data available at present time, We shall give the expressions for α_V and α_A in two different gauge models- in the standard one and in a vector-like extension of the standard model in which the neutral current of the charged leptons is a pure vector /22-24/. We restrict our discussion to the case of the lepton scattering on a target with equal number of protons and neutrons. From (6),(28) and (29) it follows that in the standard model

$$\alpha_V = \frac{9}{5}\left(1 - \frac{20}{9}\sin^2\theta_W\right),$$
$$\alpha_A = \frac{9}{5}\frac{y(2-y)}{1+(1-y)^2}. \qquad (30)$$

Note that eq.(30) has been derived in the valence quark approximation(the relevant contributions of the u- and d-quarks have been taken into account only). Using the eqs.(6),(I4),(I5),(I9) and (30) one can easily obtain the expressions for the asymmetries $A_\mp$, $B(\lambda)$ and C in the standard theory:

$$A_\mp = \frac{9}{10}\rho\left[(-1+4\sin^2\theta_W)\frac{y(2-y)}{1+(1-y)^2} \mp \left(1-\frac{20}{9}\sin^2\theta_W\right)\right], \qquad (31)$$

$$B(\lambda) = \frac{9}{10}\rho\left[1+\lambda(-1+4\sin^2\theta_W)\right]\frac{y(2-y)}{1+(1-y)^2}, \qquad (32)$$

$$C = \frac{9}{10}\rho\frac{y(2-y)}{1+(1-y)^2}. \qquad (33)$$

The dependence of the P-odd asymmetries A_- and A_+ on $\sin^2\theta_W$ for $q^2 = 200$ GeV^2 and for two values of the variable y, namely for $y = 0.5$ and $y = I$ are presented graphically in Fig.2a and Fig.2b, respectively. As is seen from these figures, the asymmetries A_- and A_+ have absolutely different behaviour.

It is well known that the standard theory is consistent with neutral current data if $\sin^2\theta_W = 0.3 \pm 0.I$. For the values of the parameter $\sin^2\theta_W$ close to $\frac{1}{3}$, the asymmetry A_- is rather small. The asymmetry A_+ in this region is $\sim$ I%. The dependence of the asymmetry $B(1)$ on $\sin^2\theta_W$ for $y = I$ and $y = 0.5$ and $q^2 = 200(\mathrm{GeV})^2$ is presented in Fig.3. For $\sin^2\theta_W \simeq \frac{1}{3}$ the asymmetry $B(1)$ is roughly 2%.

An extension of the standard $SU(2)\times U(1)$ gauge theory with additional right-handed doublets

$$\begin{pmatrix} N_e & N_\mu \\ e & \mu \end{pmatrix}_R \qquad \begin{pmatrix} u & c \\ b & t \end{pmatrix}_R \tag{34}$$

was considered in [22-24]. Here N_e and N_μ are the field operators of two heavy neutral leptons, b and t are the field operators of two heavy quarks with charges $(-\frac{1}{3})$. This model has many interesting features (suppression of the parity vioation effects in heavy atoms[22,24], $\mu\to e\gamma$ decay rate close to the experimental upper limit[25], etc.). The neutral currents of the charged leptons and hadrons here have the form (4) and (5), respectively, with

$$\begin{aligned} g_V &= -1+2\sin^2\theta_W, \quad g_A = 0, \\ v_u &= -1-\frac{4}{3}\sin^2\theta_W, \quad a_u = 0, \\ v_d &= -\frac{1}{2}+\frac{2}{3}\sin^2\theta_W, \quad a_d = -\frac{1}{2}. \end{aligned} \tag{35}$$

Since in this scheme $g_A=0$, the asymmetries $A_\mp$, B and C satisfy the relations:

$$\begin{aligned} A_+ &= A_- = A \\ C &= 0 \\ B(\lambda) &= \lambda A. \end{aligned} \tag{36}$$

From (32) and (35) one can get [24] in the valence quark approximation:

$$\begin{aligned} \alpha_A &= \frac{3}{5}\,\frac{y(2-y)}{1+(1-y)^2}, \\ A &= \rho(-1+2\sin^2\theta_W)\frac{3}{5}\,\frac{y(2-y)}{1+(1-y)^2}. \end{aligned} \tag{37}$$

Let us remark that the considered asymmetries do not depend on α_V in this model.

The dependence of the asymmetry A on the parameter $\sin^2\theta_W$ for $q^2=200\,(\text{GeV})^2$ and $y=0.5$; 1 is presented in Fig.4. It is seen that for $\sin^2\theta_W<0.5$ the asymmetry A is negative and for $\sin^2\theta_W \sim \frac{1}{3}$ it is approximately $\sim 1\%$.

5. Conclusion

It is quite clear that the search for a weak interaction between charged leptons and hadrons is of great importance for our understanding of the nature of the weak interaction. The possibilities of the experiments with high energy muon beams undoubtedly should be used for this purpose.

In conclusion we would like to note that the discovery of the parity violation effects due to the interference of the diagrams with exchange of a photon and of a Z^0-boson would give a unique possibility to determine the sign of the weak coupling constant G./26/

We are deeply grateful to B.M.Pontecorvo, C.Rubbia and I.Savin for valuable discussions.

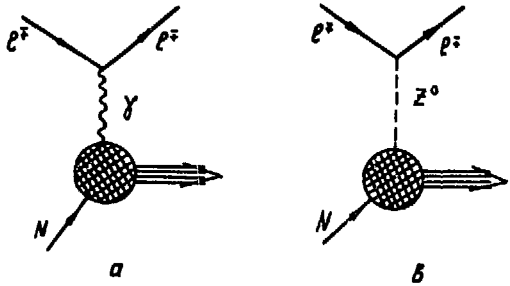

Fig.I. The diagrams for the processes $\ell^{\mp} + N \to \ell^{\mp} + X \; (\ell = e, \mu)$ with exchange of a photon (Fig.Ia) and a Z^0-boson (Fig.Ib).

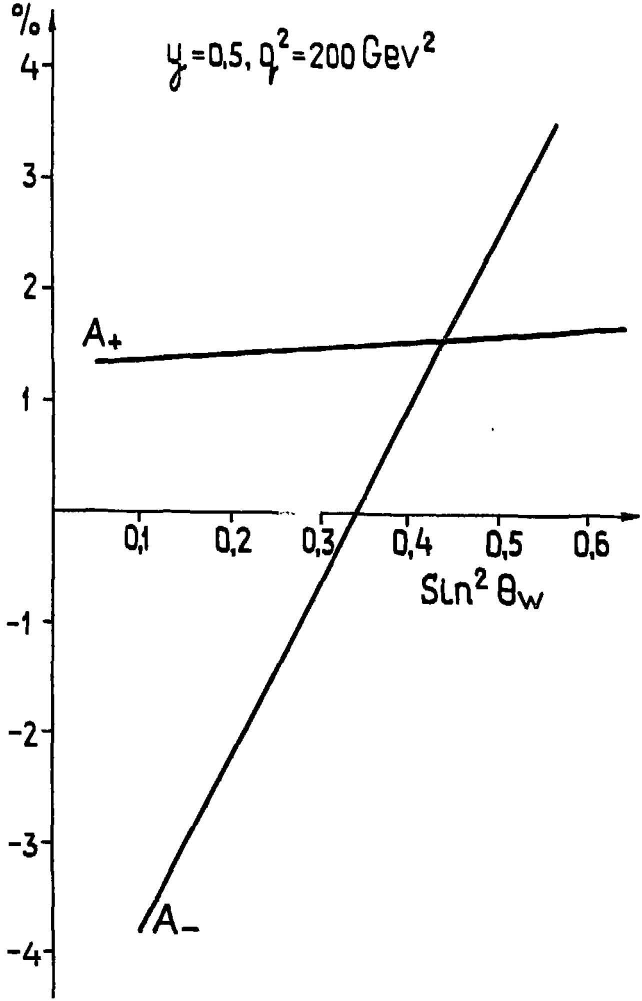

Fig. 2a

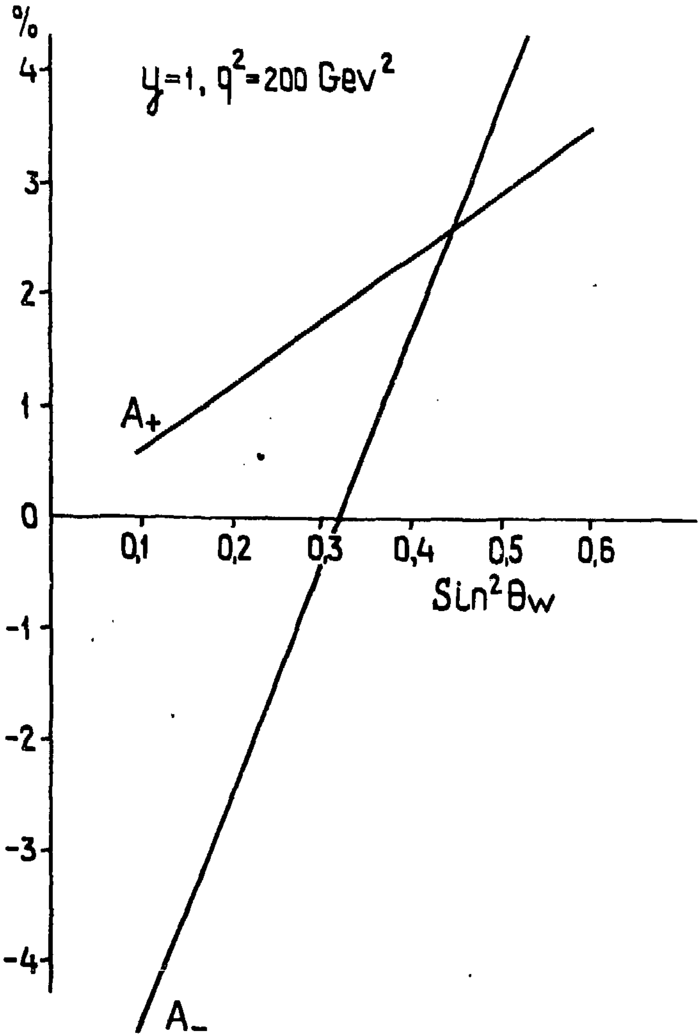

Fig.2 The dependence of the asymmetries A_- and A_+ on $\sin^2\theta_W$ in the standard SU(2)XU(I) gauge theory for q^2=200(GeV)^2 and y=0.5(Fig.2a) and y=I(Fig.2b).

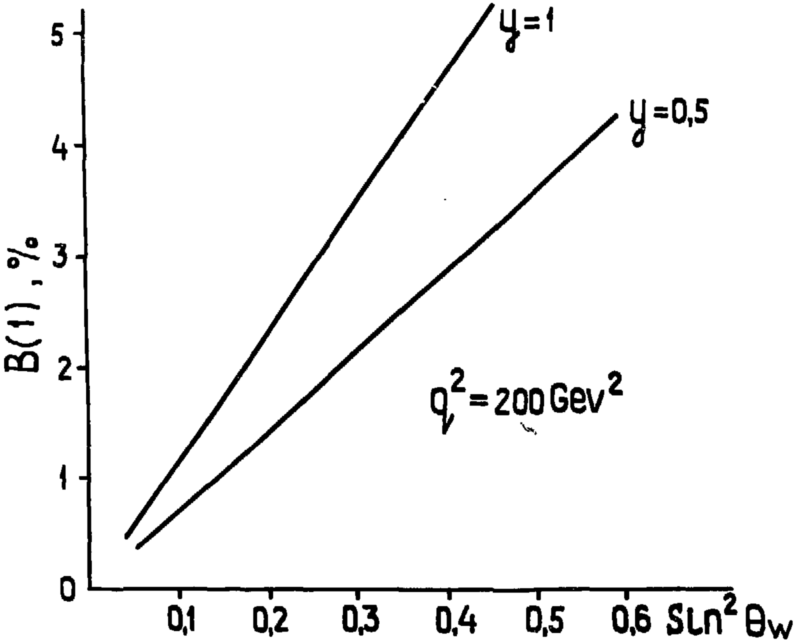

Fig.3 The dependence of the asymmetry B(I) on $\sin^2\theta_W$ in the standard SU(2)XU(I) gauge theory for q^2=200(GeV)^2 and for y=0.5;I.

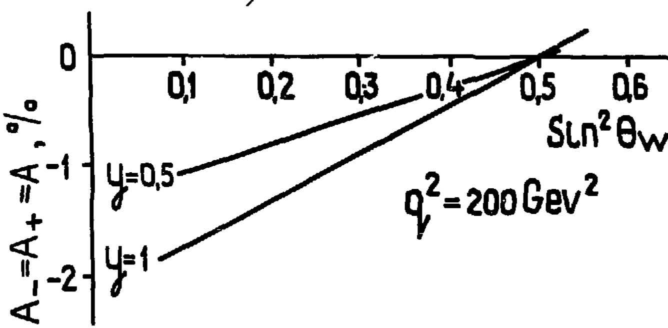

Fig.4 The dependence of the asymmetry A on $\sin^2\theta_W$ in the SU(2)XU(I) gauge theory [22-24] with a pure vector neutral current of the charged leptons (q^2=200(GeV)^2, y=0.5;I).

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