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The Deep Inelastic Neutrino-Nucleon Scattering and Spin Nucleon

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Abstract. The possibility of the extraction of new information about the quark contributions in the nucleons spin by a set of measurable quantities is discussed for deep inelastic neutrino scattering on polarized targets via neutral weak current.

1. The essential progress in investigation of the polarized deep inelastic scattering (DIS) of muons and electrons was achieved at CERN, SLAC and DESY (see [1]-[3] and references therein). All modern data from different experiments is in the good mutual agreement. The results of these experiments demonstrate the violation of the Ellis-Jaffe sum rule and the confirmation of the Bjorken sum rule at the 10 % level. Using all data one can makes the conclusion about the total quark contribution $\sim 30\%$ and the essentially negative contribution from the strange quarks. However, the origin of the nucleon spin can not been finally ascertained as far as the gluon polarization is not good fixed now.

The QCD analysis of all polarized data is important for the solution of the nucleon spin problem. Therefore the neutrino experiment data is necessary.

The use of DIS neutrino on polarized nucleons was proposed several years ago for a study of nucleon spin structure [4]. There were proposed the schemes for the determination of the quark contributions to the nucleon spin. Another approach to investigation of nucleon spin in neutrino reactions by charged current was considered in paper [5]. In present work the approach [5] is used for analysis of polarization of neutrino-nucleon DIS with neutral current:

$$\nu(\overline{\nu}) + N \to \nu(\overline{\nu}) + X. \tag{1}$$

2. The total absorption cross section of virtual Z-boson by polarized nucleon have been calculated. The cross sections $\sigma_{1\backslash 2(3\backslash 2)}$ and $\sigma_{-1\backslash 2(-3\backslash 2)}$ with the total angular momentum system Z-boson-nucleon $\pm 1\setminus 2$ and $\pm 3 \setminus 2$ survive in scaling limit only. They are

$$\begin{aligned} \sigma_{1\backslash 2(3\backslash 2)} &\sim \frac{F_2(x)}{2x} - F_3(x)\setminus 2 \pm g_1(x) \mp g_6(x), \\ \sigma_{-1\backslash 2(-3\backslash 2)} &\sim \frac{F_2(x)}{2x} + F_3(x)\setminus 2 \pm g_1(x) \pm g_6(x) \end{aligned} \tag{2}$$

where $F_{1,3}(x)$ and $g_{1,6}(x)$ are the structure functions of nucleon.

Virtual polarization asymmetries we obtain by (2):

$$A_1(x) = \frac{(\sigma_{1\backslash 2} + \sigma_{-1\backslash 2}) - (\sigma_{3\backslash 2} + \sigma_{-3\backslash 2})}{(\sigma_{1\backslash 2} + \sigma_{-1\backslash 2}) + (\sigma_{3\backslash 2} + \sigma_{-3\backslash 2})} = \frac{2xg_1(x)}{F_2(x)}, \tag{3}$$

$$A_6(x) = \frac{(\sigma_{1\backslash 2} - \sigma_{-1\backslash 2}) - (\sigma_{3\backslash 2} - \sigma_{-3\backslash 2})}{(\sigma_{1\backslash 2} - \sigma_{-1\backslash 2}) + (\sigma_{3\backslash 2} - \sigma_{-3\backslash 2})} = \frac{2xg_6(x)}{xF_3(x)}, \tag{4}$$

The measurable asymmetries $A_{\nu,\bar\nu}(x,y)$ [4] can be expressed by asymmetries (3),(4):

$$A_{\nu,\bar\nu}(x,y) = \frac{y_+ A_6(x) F_3(x) \pm y_- A_1(x) F_2(x)}{y_+ F_2(x) \pm y_- F_3(x)}, \tag{5}$$

where x and y are standard scaling variables, $y_1 = 1 - y, y_\pm = 1 \pm y_1^2$.

Asymmetries $A_{1,6}(x)$ have been obtained from (5):

$$A_1(x) = \frac{1}{2}[\frac{xF_3(x)}{F_2(x)}(A_\nu + A_{\bar\nu}) + \frac{y_+}{y_-}(A_\nu - A_{\bar\nu})],$$
$$A_6(x) = \frac{1}{2}[\frac{F_2(x)}{xF_3(x)}(A_\nu + A_{\bar\nu}) + \frac{y_+}{y_-}(A_\nu - A_{\bar\nu})], \tag{6}$$

and by means of (3),4) one extracts polarization structure functions $g_{1,6}(x)$.

3. The $g_{1,6}(x)$ were obtained in the quark parton model (QPM) in the following form:

$$g_1(x) = \frac{1}{2}\sum_f (g_V^2 + g_A^2)_{q_f}(\Delta q_f(x) + \Delta\overline{q_f}(x)), \tag{7}$$

$$g_6(x) = \sum_f (g_V g_A)_{q_f}(\Delta q_f(x) - \Delta\overline{q_f}(x)), \tag{8}$$

$(\Delta\overline{q_f}(x))\Delta q_f(x)$ in (7),(8) are the functions of (anti)quarks distribution $f = u, d, s$;

$$(g_V)_u = \frac{1}{2} - \frac{4}{3}\sin^2\theta_W, (g_A)_u = \frac{1}{2},$$
$$(g_V)_{d,s} = -\frac{1}{2} + \frac{2}{3}\sin^2\theta_W, (g_A)_{d,s} = -\frac{1}{2},$$

Let us consider deutron polarized target.

The polarization structure functions of deutron are:

$$g_{1,6}^d(x) = \frac{1}{2}(g_{1,6}^p(x) + g_{1,6}^n(x))(1 - 1.5\omega), \tag{9}$$

where $\omega \simeq 0.05$ is the D-wave state probability of deutron.

Then for this moments one obtains following expression:

$$\Gamma_1^d = \frac{1}{4}[(g_V^2 + g_A^2)_u(\Delta u + \Delta\overline{u} + \Delta d + \Delta\overline{d}) +$$
$$(g_V^2 + g_A^2)_d(\Delta u + \Delta\overline{u} + \Delta d + \Delta\overline{d} + 2(\Delta s + \Delta\overline{s}))](1 - 1.5\omega), \tag{10}$$
$$\Gamma_6^d = \frac{1}{2}\sum_{f=u,d}(g_V g_A)_f(\Delta u_v + \Delta d_V)](1 - 1.5\omega) \tag{11}$$

The individual contributions from quarks one can obtain by means of some additional measurable quantity, e.g. a_3 and a_8,which in QPM are defined as:

$$a_3 = (\Delta u + \Delta\overline{u}) - (\Delta d + \Delta\overline{d}),$$
$$a_8 = \frac{1}{\sqrt{3}}[\Delta u + \Delta\overline{u} + \Delta d + \Delta\overline{d} - 2(\Delta s + \Delta\overline{s})], \tag{12}$$

So,from (10), and (12) one have:

$$[\Delta u + \Delta\overline{u}]([\Delta d + \Delta\overline{d}]) = \frac{1}{2}(\sqrt{3}a_8 \pm a_3) + \frac{1}{a_q}[\frac{4\Gamma_1^d}{(1-1.5\omega)} - \sqrt{3}a_8 \sum_{f=u,d}(g_V^2 + g_A^2)_f], \quad (13)$$

$$\Delta s + \Delta\overline{s} = \frac{1}{a_q}[\frac{4\Gamma_1^d}{(1-1.5\omega)} - \sqrt{3}a_8 \sum_{f=u,d}(g_V^2 + g_A^2)_f],$$

where

$$a_q = 2[(g_V^2 + g_A^2)_u + 2(g_V^2 + g_A^2)_d].$$

One gets with (11) summary contribution from valence quarks Δq_V:

$$\Delta q_V = \Delta u_V + \Delta d_V = \frac{2\Gamma_6^d}{\sum_{f=u,d}(g_V g_A)_f(1-1.5\omega)}. \quad (15)$$

Thus, the way of extraction of polarization structure functions $g_{1,6}(x)$ from experimental data is proposed in this paper. The approach for determination contribution of valence and individual quarks contribution into nucleon spin is suggested.

References

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