DEPENDENCE OF ASYMMETRIES ON SPIN STRUCTURE FUNCTION g_2 IN ELECTRON–DEUTERON SCATTERING

J. Kraśkiewicz

Institute of Physics, Maria Curie-Skłodowska University
Radziszewskiego 10, 20-031 Lublin, Poland

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We analyse inclusive scattering of the polarised electron on the polarised deuteron in the Plain Wave Impulse Approximation (PWIA). Assuming two kinds of functions for $g_2(x)$, *e.g.* $g_2 = 0$ and $g_2 = g_2^{WW}$, the longitudinal and transverse asymmetries are calculated versus the electron energy loss for the different initial electron energy and the scattering angle.

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1. Introduction

This paper is the continuation of the previous one [1], where I described only the quasi-elastic scattering of polarised electrons from the polarised deuteron in the Plain Wave Impulse Approximation (PWIA). There I calculated the differential cross sections and asymmetries.

The elastic and inelastic electron scattering from nuclei is a powerful and fruitful method to investigate the nuclear structure. Current experiments of this kind are so precise that we can observe phenomena connected with spins of electrons and nuclei. The spin structure of nucleons is now examined very intensively. There exists a broad experimental program of electron–deuteron scattering studies at Jefferson Lab and SLAC with the polarised lepton beam and the deuteron target.

Let us consider inclusive scattering in one photon exchange approximation. Now we must take into account not only the elastic but also inelastic channel in the elementary electron collision with quasi-free nucleons in the nucleus.

The PWIA method used in this paper to calculate the differential cross section (d.c.s.) in the inclusive scattering of polarised electrons from polarised deuterons is based on the assumption that an ingoing lepton interacts with only a single, quasi-free nucleon in the nucleus and ejects it. The nucleon leaves the nucleus with a sufficiently high energy that the process can be treated approximately as having occurred without strong effects from final-state interactions.

I would like to mention that there exist more refined approaches which take into account final-state interactions [2] or relativistic effects [3–6] but such corrections are now smaller than experimental uncertainties in measurements of asymmetries. So I use the de Forest's recipe for off-shell modifications to simulate to some extent the neglected interaction effects.

As was shown by de Forest [7], the problem of the lepton-nucleus interaction within the above assumptions is reduced to the more fundamental lepton–nucleon scattering and to the calculation of the nucleus spectral function.

The structure of nucleons in that elementary process is described by the $F_1^p(q^2)$, $F_2^p(q^2)$, $F_1^n(q^2)$, $F_2^n(q^2)$ elastic structure functions, $W_1^p(x,q^2)$, $W_2^p(x,q^2)$, $W_1^n(x,q^2)$, $W_2^n(x,q^2)$ inelastic structure functions and $g_1^p(x,Q^2)$, $g_2^p(x,Q^2)$, $g_1^n(x,Q^2)$, $g_2^n(x,Q^2)$ polarised inelastic ones.

The elastic and inelastic structure functions are quite well known experimentally but a lot of effort is now being put into extracting polarised structure functions from deep inelastic e–p or e–d cross-sections asymmetry measurements. The PWIA expressions involve independently all proton and neutron structure functions but the polarised structure functions enter as a combination $g_1^p+g_1^n$ and $g_2^p+g_2^n$. So we have substituted $2g_{1,2}^d(1-1.5\omega_D)$ for $g_{1,2}^p+g_{1,2}^n$ in the numerical calculations ($\omega_D = 0.0577$ is a probability that a deuteron is in a D-state [4]). From the basic point of view we should use independently known $g_{1,2}^p$ and $g_{1,2}^n$ but this substitution is done only because of little experimental knowledge of neutron polarised structure functions and that they are mostly deduced from the deuteron structure functions.

The function $g_2(x,Q^2)$ is known experimentally and theoretically with less accuracy than $g_1(x,Q^2)$ one. In this paper I calculate the asymmetries for two theoretically possible forms of $g_2(x,Q^2)$: one, assuming $g_2(x,Q^2)=0$ and the other for the form predicted by QCD [12]

$$g_2(x,Q^2) \approx g_2^{WW} = -g_1(x,Q^2) + \int_x^1 \frac{g_1(y,Q^2)}{y} dy\,. \tag{1}$$

In E143 experiments [8] both cases $g_2=0$ and $g_2=g_2^{WW}$ were consistent with their data.

In this paper I show that there is a big difference between the calculated transverse asymmetries $A_\perp$ with $g_2=0$ and $g_2=g_2^{WW}$ for the scattering angle greater than $10°$.

Transverse asymmetries $A_\perp$ are very sensitive to the change of the shape of $g_2(x)$ and to the scattering angle θ so experiments in the kinematical region where $\theta > 10^\circ$ can determine the values of $g_2(x)$ with more precision.

The calculations of asymmetries were performed for such kinematical regions where differential cross section is greater than 0.1 pb/GeV/sr.

The structure of nucleus is described by the nucleon spectral function $P(\vec{p}, \varepsilon)$.

De Forest proposed the method to describe the scattering of an electron by an off-shell nucleon. The nucleon is represented by a plane wave. The energy transfer $\tilde{\omega}$ to that bounded nucleon is less than electron energy loss ω for two reasons. One is the binding energy of the nucleon. The other is the recoil of the remaining nucleus (in our case the remaining nucleon). Consequently the struck nucleon in the initial state has an energy diminished by the kinetic energy of the recoiling nucleon and its momentum is opposite to the remaining nucleon because the deuteron is in the rest. These two reasons are the cause that the struck nucleon is off-shell.

The framework of my calculations of the d.c.s. is based on the paper [13,14] by Benhar *et al.* with the generalisation on the polarised particles.

In Sec. 2 I present the calculations of the differential cross-section of the considered process within PWIA using relativistic dynamics. In Sec. 3 I define the longitudinal and transverse asymmetries measured in the experiments. In Sec. 4 the calculated transverse asymmetries for two cases, $g_2 = 0$ and $g_2 = g_2^{WW}$, are presented and compared with the experimental ones in the Fig. 4 for the different ingoing electron energy and scattering angle *versus* transfer electron energy.

The asymmetries for a given energy of an ingoing electron and different scattering angle versus energy loss ω and for cases, $g_2 = 0$ and $g_2 = g_2^{WW}$, are provided in Figs 5,6.

The total differential cross-sections in the same kinematical region are presented in Fig. 7.

2. Electron-nucleus scattering within PWIA

The differential cross-section for the inclusive reaction

$$e + A \to e' + \text{ anything} \tag{2}$$

is given by

$$\frac{d^2\sigma^2}{d\Omega dE'} = \frac{\alpha^2}{q^4}\frac{E'}{E} L^{\mu\nu} W^A_{\mu\nu}(q)\,, \tag{3}$$

where q is the 4-momentum transfer, E, E' — the energies of the ingoing and outgoing electron, $\alpha = \frac{1}{137}$, $L^{\mu\nu}$ and $W^A_{\mu\nu}$ are respectively the lepton and nuclear tensors.

The nuclear tensor $W^A_{\mu\nu}$ describes the structure of a nucleus and in PWIA is given by [7]

$$W^A_{\mu\nu}(q) = \int d^3p d\varepsilon P(\vec{p},\varepsilon)[Z\tilde{W}^p_{\mu\nu}(\vec{p},\varepsilon,q) + N\tilde{W}^n_{\mu\nu}(\vec{p},\varepsilon,q)] \,, \tag{4}$$

where the nucleon spectral function $P(\vec{p},\varepsilon)$ represents the probability distribution of removing a particle of momentum $\vec{p}$ from the nucleus ground state leaving the residual system with an excitation energy equal to ε (including the recoil energy).

The off-shell proton and neutron tensors $\tilde{W}^p_{\mu\nu}$, $\tilde{W}^n_{\mu\nu}$ describe the interaction of a virtual photon with an individual, bound nucleon in the nucleus and are related to the structure functions of the free nucleons.

In PWIA the two channels contribute to the inclusive reaction (2):
— elastic electron-nucleon scattering (Fig. 1)
— inelastic electron-nucleon scattering (Fig. 2).

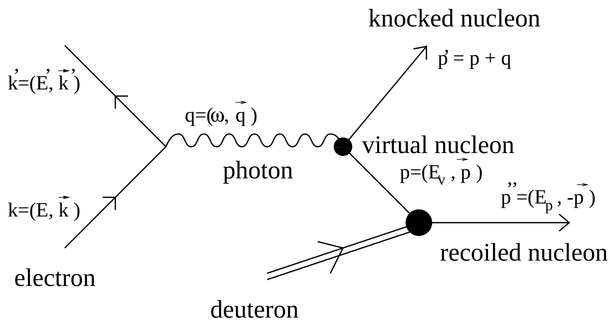

Fig. 1. The kinematics of the quasi-elastic electron–deuteron scattering in the PWIA; $E_p = \sqrt{\vec{p}^2 + M^2}$, $E_v = 2M - E_d - E_p$.

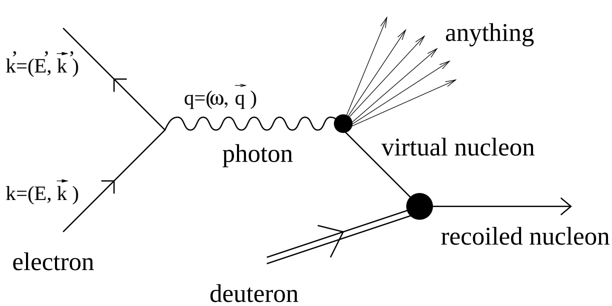

Fig. 2. The diagram of the inelastic electron–nucleon scattering in the PWIA.

Since the scattering process involves a bound nucleon, a fraction of the energy transferred by the virtual photon goes into the excitation energy and recoil of the residual $(A-1)$ nucleus. In Ref. [7] de Forest proposed for the quasi-elastic scattering to relate $\tilde{W}^p_{\mu\nu}$, $\tilde{W}^n_{\mu\nu}$, to the free nucleon structure functions $F_1(Q^2), F_2(Q^2)$ and to the free nucleon spinors $u(p)$ but taking the energy transfer $\tilde{\omega}$ to the struck nucleon of momentum $\vec{p}$ as:

$$\tilde{\omega} = \sqrt{(\vec{p}+\vec{q})^2 + M^2} - \sqrt{\vec{p}^2 + M^2} = \omega - E_d - (\sqrt{\vec{p}^2 + M^2} - M)\,, \quad (5)$$

where $\vec{q}$, ω are respectively electron momentum transfer and energy loss, E_d is the deuteron binding energy and M is the nucleon mass.

The off-shell current for the elastic photon–nucleon interaction is taken in the form

$$j_\mu = \bar{u}(p')\left[\gamma_\mu F_1(q^2) - i\sigma^{\mu\nu}\,\tilde{q}_\nu \frac{F_2(q^2)}{2M}\right] u(p)\,, \quad (6)$$

where $\tilde{q} = (\tilde{\omega}, \vec{q})$.

Whenever one applies the one-body electromagnetic current operator not to a free nucleon, but to a nucleon bound in the nucleus, one needs to introduce an off-shell prescription. Currently, there exists no unique and obvious microscopic description of this off-shell behaviour. There are only ad hoc prescriptions which lead to differing between themselves results (especially in the cross sections) for certain kinematics. Fortunately, this uncertainties are less for the ratio of the cross sections as it happens for the asymmetries. The discussion of these procedures can be found in [6,7].

The d.c.s. for the scattering of a polarised electron on a polarised deuteron based on the above assumptions is given by [15]

$$\frac{d^2\sigma}{d\Omega dE'} = \int d^3p d\varepsilon\, P(\vec{p},\varepsilon)\left[\sigma^{\mathrm{el}}_{ep} + \sigma^{\mathrm{el}}_{en} + \sigma^{\mathrm{inel}}_{ep} + \sigma^{\mathrm{inel}}_{en}\right]\,, \quad (7)$$

where

$$\sigma^{\mathrm{el(inel)}}_{ep(n)}(\vec{q},\vec{p},\tilde{\omega},s,S) = \frac{\alpha^2}{q^4}\frac{E'}{E}\frac{M}{E_p} L^{\mu\nu}\tilde{W}^{p(n)}_{\mu\nu} \quad (8)$$

is the off-shell, elementary elastic (inelastic) electron–nucleon d.c.s. for the moving nucleon with energy $E_p \equiv p^0 = (\sqrt{\vec{p}^2 + M^2})$, s is the spin of ingoing electron and partial polarisation 4-vector S of nucleon is defined as

$$S^\mu \equiv \left(\Pi^3 \frac{|\vec{p}|}{M}, \Pi^1, \Pi^2, \Pi^3 \frac{p^0}{M}\right)\,, \quad (9)$$

with the properties [16]

$$\begin{aligned}
&|\boldsymbol{\Pi}|^2 \equiv (\Pi^1)^2 + (\Pi^2)^2 + (\Pi^3)^2 \leq 1\,,\\
&S^\mu p_\mu = 0\,,\\
&S^\mu S_\mu = -\sqrt{(\Pi^1)^2 + (\Pi^2)^2) + (\Pi^3)^2}\,.
\end{aligned} \tag{10}$$

In the particle rest frame $p = (M, 0)$, $S^\mu = (0, \vec{\vec{S}})$, where $\vec{\vec{S}}$ is a unit 3-vector pointing in the direction of the particle spin. The "vector" $\boldsymbol{\Pi}$ is called the polarisation vector of the beam.

The deuteron spectral function $P(\vec{p}, \varepsilon)$ can be expressed in terms of the momentum distribution $n_d(\vec{p})$ of the nucleons in the deuteron [17]

$$P(\vec{p}, \varepsilon) = n_d(|\vec{p}|)\delta(\varepsilon - E_d - \sqrt{\vec{p}^2 + M^2} + M)\,. \tag{11}$$

The deuteron momentum distribution is normalised as follows

$$4\pi \int\limits_0^\infty p^2 n_d(p)dp = 1\,. \tag{12}$$

The nucleon polarisation in the deuteron is equal to the double value of the spin expectation value $\langle\sigma_N\rangle$ of the nucleon in a deuteron and is given by the $P(S)$ and $P(D)$ probabilities of the two-nucleon bound state wave function according to [4]

$$|\boldsymbol{\Pi}| = P(S) - \tfrac{1}{2}P(D) = 1 - 1.5P(D) = 0.9135\,. \tag{13}$$

In turn we consider the elementary inelastic scattering of polarised electrons on polarised nucleons. We denote by m the electron mass, by k and k' the initial and final lepton four-momentum. Lepton tensor $L_{\mu\nu}$ is given by

$$\begin{aligned}
L_{\mu\nu}(k, s, k') &= 2L^{(S)}_{\mu\nu}(k, k') + 2iL^{(A)}_{\mu\nu}(k, s, k')\,,\\
L^{(S)}_{\mu\nu} &= k_\mu k'_\nu + k'_\mu k_\nu - g_{\mu\nu}(k \cdot k' - m^2)\,,\\
L^{(A)}_{\mu\nu} &= m\epsilon_{\mu\nu\alpha\beta}s^\alpha(k - k')^\beta\,.
\end{aligned} \tag{14}$$

The hadron tensor $W_{\mu\nu}$ for a free nucleon is defined in terms of four structure functions as

$$W_{\mu\nu}(q, p, S) = W^{(S)}_{\mu\nu}(q, p) + iW^{(A)}_{\mu\nu}(q, p, S)\,, \tag{15}$$

with

$$\begin{aligned}
\frac{1}{2M}W^{(S)}_{\mu\nu}(q,p) &= \left(-g_{\mu\nu}+\frac{q_\mu q_\nu}{q^2}\right)W_1(p\cdot q,q^2) \\
&+\left[\left(p_\mu-\frac{p\cdot q}{q^2}q_\mu\right)\left(p_\nu-\frac{p\cdot q}{q^2}q_\nu\right)\right]\frac{W_2(p\cdot q,q^2)}{M^2}\,, \\
W^{(A)}_{\mu\nu}(q,p,S) &= \frac{2M}{p\cdot q}\varepsilon_{\mu\nu\alpha\beta}q^\alpha\left\{S^\beta g_1(x,Q^2)+\left[S^\beta-\frac{(S\cdot q)p^\beta}{(p\cdot q)}\right]g_2(x,Q^2)\right\}\,,
\end{aligned} \tag{16}$$

where $Q^2=-q^2$ and $x=Q^2/(2p\cdot q)$. In the case of the off-shell nucleon we substitute $\tilde{q}=(\tilde{\omega},q)$ for $q=(\omega,q)$ in the hadronic tensor $W_{\mu\nu}$.

Within the above prescription we impose the requirement of gauge invariance

$$Q_\nu W^{\mu\nu}(\tilde{q},p,s)=W_{\mu\nu}(\tilde{q},p,s)Q^\mu=0 \tag{17}$$

from which one can eliminate the dependence of the off-shell nucleon tensor upon the longitudinal current.

The symmetric part of the $\sigma^{\rm inel}_{eN}$, which depends on $W^{(S)}_{\mu\nu}$, was calculated from the analytic expression given in [13]. The elastic d.c.s. $\sigma^{\rm el}_{eN}$ and antisymmetric part of $\sigma^{\rm inel}_{eN}$ was calculated with the use of (16) imposed numerically.

3. Asymmetries

Here I define the longitudinal and transverse asymmetries to be calculated and compared with the experiment. The detail discussion about the possible polarisations of particles involved in the electron–nucleus scattering is presented in [18,19]. I give the main points.

Because of the small mass of an electron only longitudinally polarised electrons are of practical interest in nuclear physics experiments. If we consider experiments where only incident particle polarisation are measured, then the cross section can be written in the general form

$$\left(\frac{d\sigma}{d\Omega}\right)^h=\Sigma-h\Delta\,, \tag{18}$$

where h is the helicity of an electron ($h=s^3=\pm1$).

The term Δ gives the contribution to the unpolarised cross section Σ when incident electron helicity is measured.

The quantity Σ and Δ can be calculated from the cross sections as follows:

$$\Sigma = \frac{1}{2}\left\{\left(\frac{d\sigma}{d\Omega}\right)^{-1} + \left(\frac{d\sigma}{d\Omega}\right)^{+1}\right\} = \left(\frac{d\sigma}{d\Omega}\right)^{\mathrm{unpol}},$$
$$\Delta = \frac{1}{2}\left\{\left(\frac{d\sigma}{d\Omega}\right)^{-1} - \left(\frac{d\sigma}{d\Omega}\right)^{+1}\right\}. \tag{19}$$

To compare the theoretical predictions of the asymmetries with the experimental data I have slightly changed the definition of Δ (change of the sign) with respect to my previous paper [1].

The target polarisation direction is specified with respect to the scattering plane as follows:
L — along the direction of the electron beam,
N — normal to the scattering plane
S — in the scattering plane, normal to the electron beam.
The longitudinal $A_{||}$ and transverse $A_{\perp}$ asymmetries are formed as follows:

$$A_{||} = \left(\frac{\Delta}{\Sigma}\right)_{\mathrm{L}}, \qquad A_{\perp} = \left(\frac{\Delta}{\Sigma}\right)_{\mathrm{S}} \tag{20}$$

The $(\Delta/\Sigma)_{\mathrm{N}}$ ratio is identically zero in our case [18].

4. Results and conclusion

The asymmetries in quasi-elastic scattering of polarised electrons from the polarised deuteron were calculated in my previous paper [1] and elementary cross sections for polarised, elastic electron–nucleon scattering can be found in [20].

For inclusive electron–deuteron scattering we must add a contribution from inelastic electron–nucleon scattering. The sum of these two channels gives the inclusive electron–deuteron differential cross section.

I use the dipole formula for the elastic structure functions G_{E}, G_{M} of a nucleon. The inelastic structure functions W_1^N, W_2^N were parameterised to fit the data and are given in [21].

The inelastic polarised structure functions $g_1^p(x,Q^2)$, $g_1^n(x,Q^2)$ enter all considered formulas as a combination $g_1^p + g_1^n$ which expresses itself by the one deuteron form factor g_1^d as

$$g_1^p + g_1^n = \frac{2g_1^d}{(1-1,5\omega_D)}, \tag{21}$$

where ω_D is a probability that the deuteron will be in a D-state and is equal $\omega_D = 0.05$ [8].

I use the fit of the structure function $g_1^d(x, Q^2)$ to the data based on the following expression [9]

$$g_1^d(x, Q^2) = \frac{A_1^d(x, Q^2)\ F_2^d(x, Q^2)}{2x(1 + R(x, Q^2))}\,. \tag{22}$$

The parameterisation of the A_1^d, F_2^d and R functions are taken as follows:

$$A_1^d(x, Q^2) = ax^\alpha(1 + bx + cx^2)\left[1 + \frac{C}{Q^2}\right] \tag{23}$$

with [8]

$$\begin{array}{lll} \alpha = 1.46 & b = 1.915 & C = 0.260 \\ a = 2.49 & c = 1.376 & \end{array}$$

$$F_2^d(x, Q^2) = A(x)\left(\frac{\ln(Q^2/\Lambda^2)}{\ln(Q_0^2/\Lambda^2)}\right)^{B(x)}\left(1 + \frac{C(x)}{Q^2}\right) \tag{24}$$

with [10]

$$\begin{aligned} A(x) &= x^{a_1}(1-x)^{a_2}\{a_3 + a_4(1-x) + a_5(1-x)^2 + a_6(1-x)^3 + a_7(1-x)^4\}\,, \\ B(x) &= b_1 + b_2 x + b_3/(x + b_4)\,, \\ C(x) &= c_1 x + c_2 x^2 + c_3 x^3 + c_4 x^4\,, \end{aligned} \tag{25}$$

$$\begin{array}{lll} Q_0^2 = 20\ \mathrm{GeV}^2 & \Lambda = 0.250\ \mathrm{GeV} & \\ a_1 = -0.04858 & b_1 = -0.008 & c_1 = -1.509 \\ a_2 = 2.863 & b_2 = -2.227 & c_2 = 8.553 \\ a_3 = 0.8367 & b_3 = 0.0551 & c_3 = -31.20 \\ a_4 = -2.532 & b_4 = 0.0570 & c_4 = 39.98 \\ a_5 = 9.145 & & \\ a_6 = -12.504 & & \\ a_7 = 5.473 & & \end{array}$$

and [11]

$$R(x, Q^2) = \frac{0.0635}{\ln(Q^2/0.04)}\left(1 + 12\frac{Q^2}{Q^2+1}\frac{0.125^2}{0.125^2 + x^2}\right) + \frac{0.5747}{Q^2} + \frac{-0.3534}{Q^4 + 0.09} \tag{26}$$

The structure function $g_2^d(x)$ is taken either $g_2^d = 0$ (dotted lines on the figures) or $g_2 = g_2^{d(WW)}$ (solid lines) where $g_2^{d(WW)}$ is the Wandzura–Wilczek twist-2 contribution (1) [12]. Function $g_2^{d(WW)}$ is plotted in Fig. 3 for $g_1(x, Q^2 = 5\ \mathrm{GeV})$ parameterised as above.

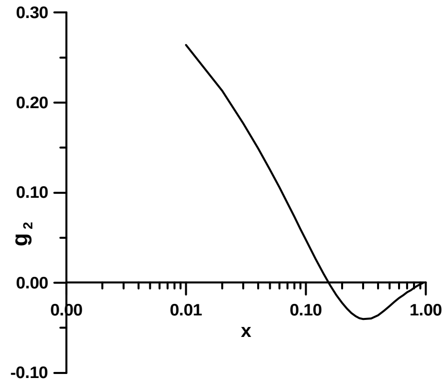

Fig. 3. Twist-2 $g_2^{d(WW)}(x)$ calculated from (1).

We assume the 100% electron longitudinal polarisation with $h = \pm 1$ and 100% deuteron polarisation.

The de Forest's prescription was used to calculate the asymmetries in Figs 4–6. Since this prescription is not unique we would like to know the deviations between different prescriptions. For this purpose we compared asymmetries calculated in two extremely different situations: for off-shell nucleons and for on-shell ones, *i.e.* without changing $q \to \tilde{q}$. It has appeared that they are the same in the whole ω range except the minimal values of ω where the differences can reach 50%. It shows that other similar pre-

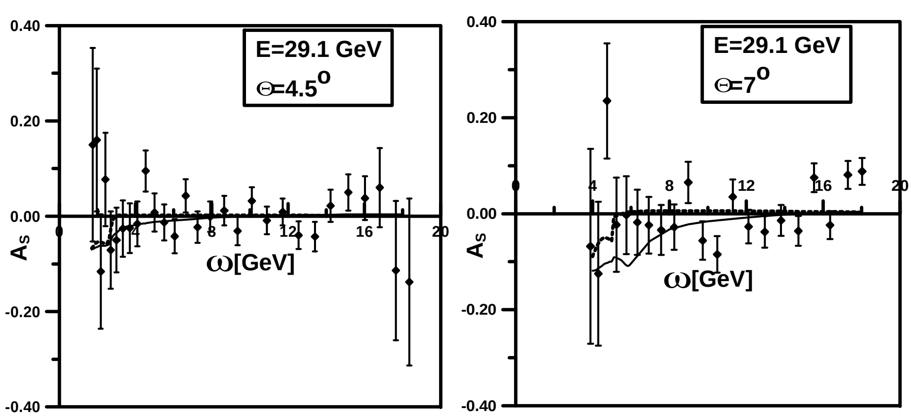

Fig. 4. The calculated transverse asymmetries $A_\perp$ (solid line for $g_2^d = g_2^{d(WW)}$ and dotted line for $g_2^d = 0$) in the inclusive electron–deuteron scattering for the initial electron energy E=29.1 GeV and two scattering angles θ compared with the experimental data (points with statistical errors).

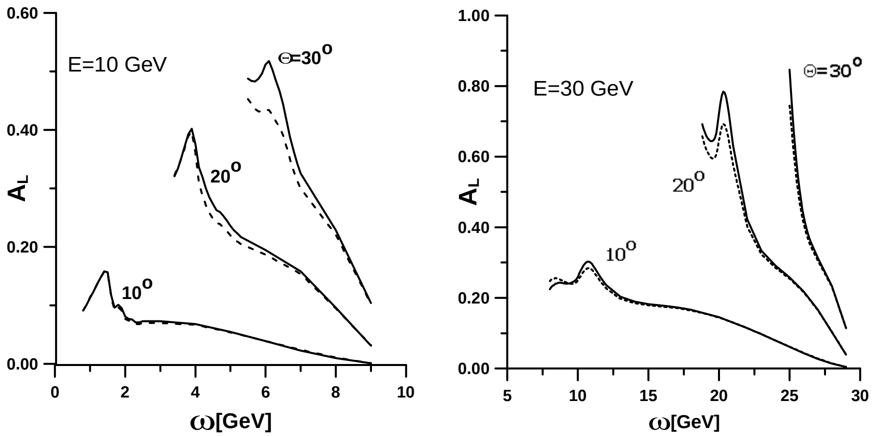

Fig. 5. The longitudinal asymmetries $A_{\parallel}$ *versus* energy loss ω for given electron energy E and scattering angles θ (solid line for $g_2^d = g_2^{d(WW)}$, dotted line for $g_2^d = 0$).

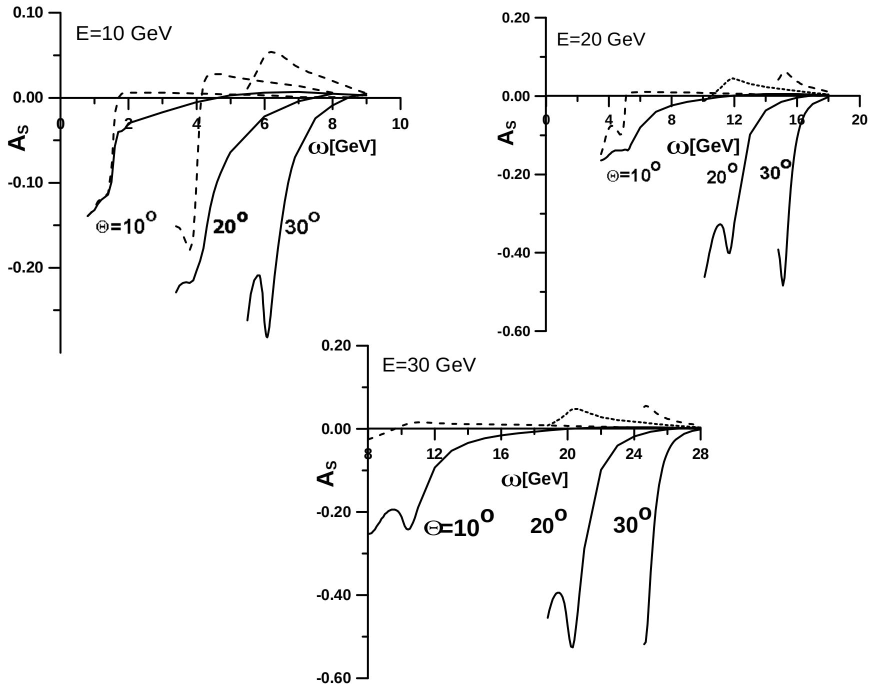

Fig. 6. The transverse asymmetries $A_{\perp}$ *versus* energy loss ω for given electron energy E and scattering angles θ (solid line for $g_2^d = g_2^{d(WW)}$, dotted line for $g_2^d = 0$).

scriptions should give comparable results for asymmetries in the case of the deuteron. The asymmetries were also calculated without the requirement of gauge invariance of modified structure functions $W^{\mu\nu}(\tilde{q}, p, S)$. Also in that case the values of asymmetries were practically the same.

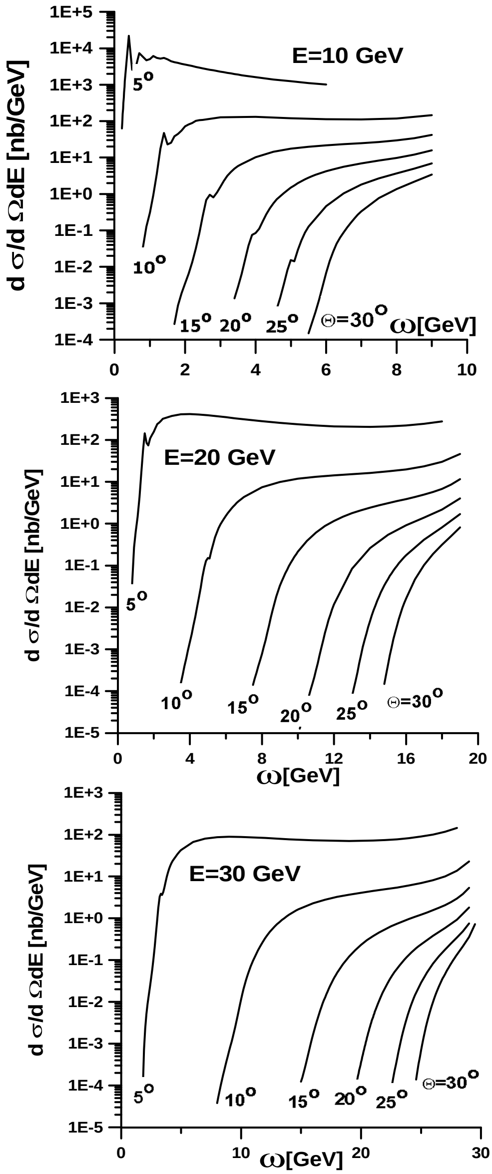

Fig. 7. The differential cross section *versus* energy loss ω for given electron energy E and scattering angles θ.

Only the calculated longitudinal asymmetries $A_{||}$ and the transverse ones $A_{\perp}$ are analysed because the ratio $(\Delta/\Sigma)_{\rm N}$ is identically zero.

Fig. 4 shows that for small scattering angles θ two cases $g_2^d = 0$ or $g_2 = g_2^{d(WW)}$ are consistent with the experimental data within measurement uncertainties.

The dependence of $A_{||}$ asymmetry on g_2 is very small (see Fig. 5).

The drastic difference in $A_{\perp}$ asymmetries between $g_2^d = 0$ and $g_2 = g_2^{d(WW)}$ is seen for the scattering angles $\theta > 10°$, which is presented in Fig. 6. The numerical calculations in PWIA show that the main contribution to the $A_{\perp}$ asymmetry due to the $g_2(x)$ function comes from the range of x for individual nucleons greater than 0.1, where function $g_2(x)$ is negative. That causes a big negative transverse asymmetry for $g_2 = g_2^{WW}$.

In Fig. 7 we can see the values of the d.c.s. in the considered regions of the energy loss for three given incoming electron energies; these values are not less than 10^{-4} nb.

The above results suggest performing inclusive electron–deuteron scattering with polarised particles where one can measure the transverse asymmetries $A_{\perp}$ for the scattering angle θ greater than $10°$ and with high electron energy. In that kinematical region it should be easier to conclude on the shape of the spin structure function $g_2(x)$.

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