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STUDY OF ELECTROWEAK RADIATIVE CORRECTIONS TO DEEP INELASTIC SCATTERING AT HERA

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Introduction

The investigation of deep inelastic electron-proton scattering at HERA requires a good quantitative understanding of radiative corrections. QED radiative corrections for this process [1-3] are known for a long time and there is very good agreement of results of different groups. Since 1978, electroweak radiative corrections (EWRC) in the standard model have been studied at Dubna [4-6] and main parts are distributed in two FORTRAN codes. The program ASYMETR [5] calculates the complete electroweak corrections to

$$\sigma_{NC} = \frac{d^2\sigma}{dx\,dy}\left[e^{\pm}(\lambda)p \longrightarrow e^{\pm}X(\gamma)\right], \tag{1}$$

whereas the program TERAD 86 [6] takes into account QED radiative corrections and the Z -exchange Born diagram in lepton-nucleon scattering at SPS energies. Both the programs treat the photon produced totally inclusive.

In a recent study [7], numerical results [8] obtained with the program ASYMETR could have not been confirmed. This disagreement together with improvements both of technical character and in the formulation obtained during the years motivate us to perform a careful reanalysis of the existing results. The investigation of the charged current cross section

$$\sigma_{CC} = \frac{d^2\sigma}{dx\,dy}\left[e^{\pm}(\lambda)p \longrightarrow \overset{(-)}{\nu}_e X(\gamma)\right] \tag{2}$$

will be added, too.

Before going into details, we would like to give a general comment. In contrast with other authors, the Dubna group uses the unitary gauge. In that gauge, certain single contributions show a more singular behaviour than in other gauges. Nevertheless, summing all the diagrams contributing to observables leads to unique gauge-independent answers. Results for neutrino elastic [9] and deep inelastic [10] scattering, for static quantities (muon decay [11], gauge boson masses [5,11] and widths [12]), and in e^+e^-- annihilation [13] show very good and sometimes absolute agreement with predictions obtained in the 't Hooft-Feynman gauge. Numerical programs developed with the unitary gauge results have been successfully applied by several collaborations at CERN (NA4, CDHS, CHARM). With no doubt, it would be very valuable to demonstrate the coincidence of EWRC to ep-scattering calculated by different groups with the use of different gauges. For this aim, we started a recalculation of the EWRC to neutral and charged current deep inelastic ep-scattering at high energies which is completely independent of the 1977/81 results and developed the new numerical program DISEP (Deep Inelastic Scattering of Electrons and Protons). Another aim of our new study is to present results in a form ensuring the possibility of comparison of contributions being gauge-invariant separately.

In the calculation of EWRC we use the quark-parton model where the ep-cross section is assumed to be an incoherent sum of electron-quark scattering processes dependent on quark distribution functions inside the nucleon. These distributions are assumed to be known here. We consider the following contributions to the neutral current reaction:

(i) The Born cross-section σ_B (Fig.1a)

$$\sigma_B = \sigma_B(\gamma) + \sigma_B(I) + \sigma_B(Z); \tag{3}$$

(ii) The photonic vacuum polarization σ_{VP} due to fermions (Fig.1b);

(iii) The QED-radiative correction σ_{QED} (except for σ_{VP} here) which contains photon bremsstrahlung and loop corrections with one additional photon propagator (Fig. 1c).

(iv) The remaining genuine weak one-loop correction, σ_{1L}, which may be prescribed by independent form factors; see below.

A similar decomposition into Born, weak and QED terms may be defined for the charged current channel but deserves some further comment which will be given in sect.3.

I. Born cross-section and one-loop corrections for the neutral current reaction

We propose to use the following notation which is very compact and exhibits explicitely which parts of the cross section are separately comparable if calculated in different gauges:

$$\frac{d^2\sigma(\lambda)}{dx\,dy} = \sigma_{1L} + \sigma_{QED}, \tag{4}$$

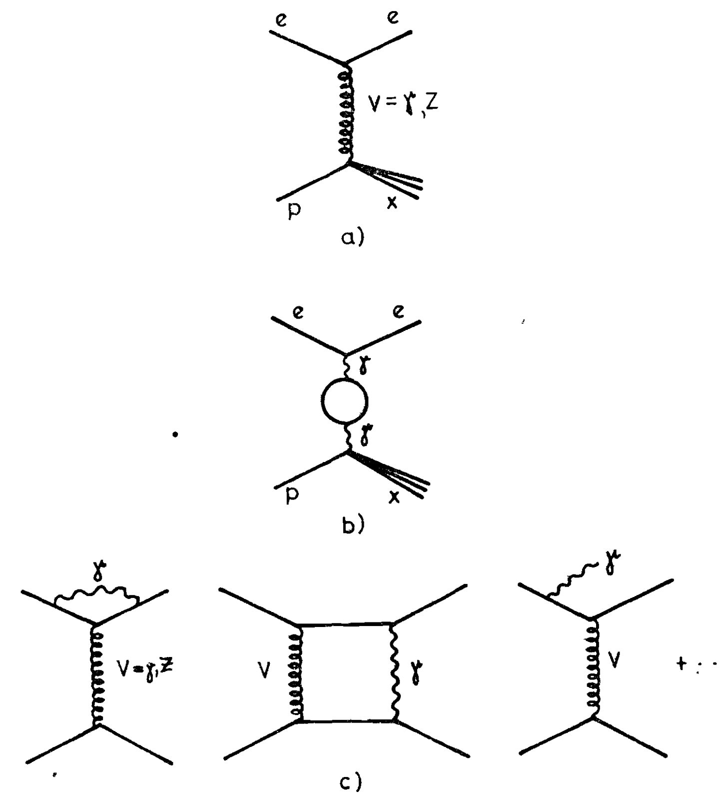

Fig.1.
QED-contributions to the neutral current cross-section.

$$\sigma_{1L} = \sigma_{1L}(\gamma) + \sigma_{1L}(I) + \sigma_{1L}(Z), \tag{5}$$

$$\sigma_{1L}(\gamma) = \frac{2\pi\alpha^2 S Q_e^2}{Q^4} y_+ F_{em}^2 \sum_{q,\bar{q}} x f_q(x, Q^2) Q_q^2, \tag{6}$$

$$\sigma_{1L}(I) = \frac{2\pi\alpha^2 S |Q_e|}{Q^4} 2\chi \Big[y_+ F_{em} \sum_{q,\bar{q}} x f_q |Q_q| \rho_{Z,q} (V_{eq} + \lambda Q_e V_q) \\ - y_- F_{em} \Big(\sum_q - \sum_{\bar{q}} \Big) x f_q |Q_q| \rho_{Z,q} (Q_e + \lambda V_e) \Big], \tag{7}$$

$$\sigma_{1L}(Z) = \frac{2\pi\alpha^2 S}{Q^4}\chi^2\Big\{y_+\sum_{q,\bar q} x f_q \rho_{Z,q}^2\left[1+V_e^2+V_q^2+V_{eq}^2+2\lambda Q_e(V_e+V_qV_{eq})\right] \tag{8}$$

$$-2y_-\Big(\sum_q - \sum_{\bar q}\Big) x f_q \rho_{Z,q}^2\left[Q_e(V_eV_q+V_{eq})+\lambda(V_eV_{eq}+V_q)\right]\Big\}.$$

The S, x, y, $Q^2 = Sxy$, $U = Q^2 - S$ are the usual kinematical variables, $y_\pm = 1 \pm (1-y)^2$; Q_q , the quark charges; and λ , the longitudinal polarization of the lepton beam; $Q_e(e^\pm)=\pm 1$.

The photonic vacuum polarization is contained in F_{em} ,

$$F_{em} = \left(1 - \frac{\alpha}{\pi}\delta_{em}\right)^{-1}, \tag{9}$$

$$\delta_{em} = \frac{2}{3}\sum_f c_f Q_f^2\left(\ln\frac{Q^2}{m_f^2} - \frac{5}{3}\right). \tag{10}$$

All the genuine weak loop corrections have been collected in a small number of gauge-invariant form factors.

The form factors $\varkappa_a$ $(a = e, q, eq)$ may be understood as process-dependent modifications by EWRC of the weak neutral current vector couplings

$$V_e = 1 - 4 s_W^2 |Q_e| \varkappa_e , \tag{11}$$

$$V_q = 1 - 4 s_W^2 |Q_q| \varkappa_q , \tag{12}$$

$$V_{eq} = 1 - 4 s_W^2 |Q_e| \varkappa_e - 4 s_W^2 |Q_q| \varkappa_q + 16 s_W^4 |Q_e Q_q| \varkappa_{eq}. \tag{13}$$

Without EWRC the V_e and V_q become the usual weak couplings V_e^0 and V_q^0 of electrons and quarks with $V_{eq}^0 = V_e^0 \cdot V_q^0$ (the axial couplings are fixed at $a_e = a_q = 1$). The explicit form of the $\varkappa_a$ will be given elsewhere. As an example, we express two of them using the notation of earlier work /11/ as follows:

$$\varkappa_e = \mathcal{F}_2^Z / \mathcal{F}_1^Z , \quad \varkappa_q = \mathcal{F}_3^Z / \mathcal{F}_1^Z . \tag{14}$$

The dependence on a heavy t-quark mass m_t may be found in /12/. Due to box-diagram contributions, the form factors $\varkappa$, ρ_Z of e^-q -scattering are different from those of $e^-\bar q$ - scattering, e.g.

$$\varkappa_q(e^-, q) = \varkappa_q(e^+, \bar q) = \varkappa_q(Sx, Q^2, Ux), \tag{15}$$

$$\varkappa_q(e^-, \bar q) = \varkappa_q(e^+, q) = \varkappa_q(Ux, Q^2, Sx). \tag{16}$$

One remaining form factor ρ_Z has to be discussed in close connection with the definition of the Born cross section which is dependent on the calculational scheme used. The original definitions of χ and ρ_Z in the one-mass-shell renormalization scheme (OMS) are

$$\chi = \frac{g^2}{16 c_W^2}\,\frac{1}{e^2}\,\frac{Q^2}{Q^2+M_Z^2}, \tag{17}$$

$$\rho_Z = \mathcal{F}_1^Z, \tag{18}$$

where we additionally fix, as usual, $g \equiv e/s_W$, $c_W^2 = 1 - s_W^2 \equiv M_W^2/M_Z^2$, and again use $\mathcal{F}_1^Z$ from /11,12/ . Two popular calculational schemes use the following definitions:

$$\chi_I = \frac{G_\mu}{\sqrt 2}\,\frac{M_Z^2}{8\pi\alpha}\,\frac{Q^2}{Q^2+M_Z^2}, \quad \rho_Z^I = (1-\delta r)\mathcal{F}_1^Z, \tag{19}$$

$$\chi_{II} = \frac{1}{16 s_W^2 c_W^2}\,\frac{Q^2}{Q^2+M_Z^2}, \quad \rho_Z^{II} = \mathcal{F}_1^Z, \tag{20}$$

$$\delta r = \frac{\alpha}{4\pi} X. \tag{21}$$

where X is introduced in /11,12/. The corresponding Born approximation is obtained by setting $F_{em} = \rho_Z = \varkappa_a = 1$, $(a = e, q, eq)$. The following relation, e.g., holds, in accordance with eq. (3):

$$\sigma_B(\gamma) = \sigma_{1L}^{\gamma}(F_{em} = 1). \tag{22}$$

In the above definitions, the χ_{II} is the OMS definition of the relative strength of electromagnetic and weak neutral interactions, whereas in the modified OMS (or, shortly, MOMS) the χ_I ,

$$\chi_I = \chi_{II}(1-\delta r)^{-1} \tag{23}$$

effectively includes already a finite renormalization mainly shifting $\alpha(0)$ to $\alpha(M_Z^2)$ thereby lowering the numerical EWRC considerably. Of course, the product $\chi \cdot \rho_Z$ is independent of the calculational scheme. Finally, we only remark that we do not discuss the problem of choice of 3 independent input parameters out of the set

$\{\alpha, G_\mu, M_Z, M_W, s_W^2 = \sin^2\theta_W\}$. This has been discussed for ep-scattering in /14/; see also /15-18/.

For illustrational purposes we use the following set of parameters as proposed in /7/:

$$
\begin{aligned}
&M_Z = 93.0 \text{ GeV}, \\
&M_W = 82.0 \text{ GeV}, \qquad \text{corresponding to } \sin^2\theta_W = 0.2226, \\
&M_H = 100.0 \text{ GeV}, \\
&m_u = m_d = 0.030 \text{ GeV}, \quad m_s = 0.150 \text{ GeV}, \quad m_b = 4.5 \text{ GeV}, \\
&\qquad m_c = 1.5 \text{ GeV}, \quad m_t = 30 \text{ GeV},
\end{aligned}
\tag{24}
$$

and the parton distribution functions f_q of the Duke and Owens /19/, type I ($Q_0^2 = 4$ GeV^2, $\Lambda_{QCD} = 0.2$ GeV).

To set a scale, in Fig.2, the e^-p Born cross- section is presented for $\lambda = 0$. For comparison, $\sigma_B(\gamma)$ is shown, too. Figure 3 contains the correction from the photonic vacuum polarization due to fermions, δF_{em}, for the mass parameters as given above. The net effect of the electroweak form factors is represented in Fig.4 both for the OMS- and MOMS-schemes through

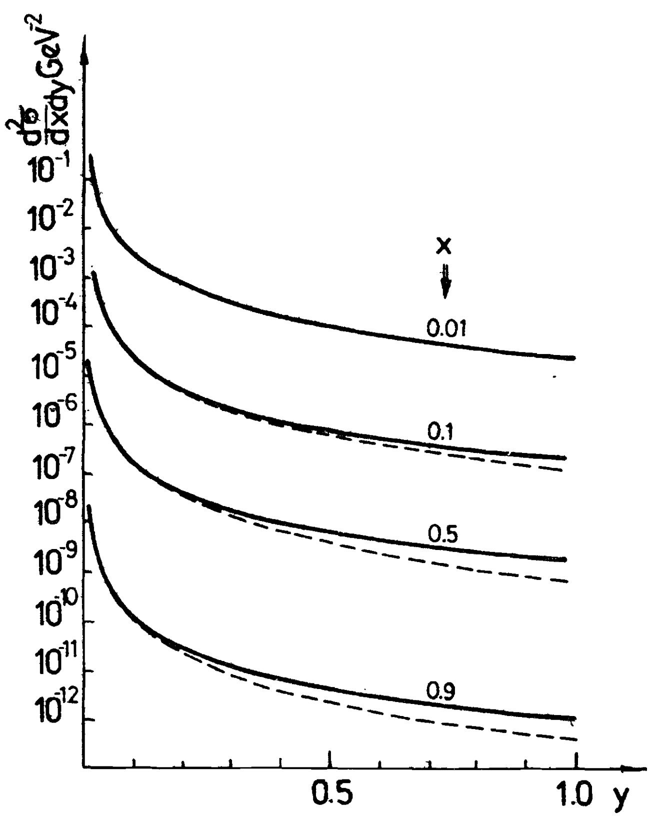

Fig.2.
Neutral current cross-section in the Born approximation with parameters as fixed in (24) in the MOMS scheme for $\lambda = 0$, $S = 10^5$ GeV^2. The QED Born cross-section is also shown (dashed line).

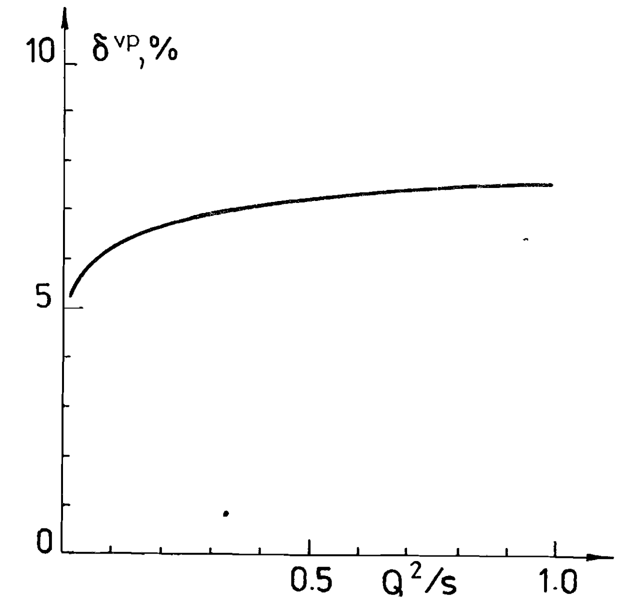

Fig.3.
The photonic vacuum polarization due to fermions for the parameters of (24).

$$
\delta_{1L} = \frac{d^2\sigma_{1L}}{dxdy}\left(\rho, \varkappa; F_{em} = 1\right) \Big/ \frac{d^2\sigma_B}{dxdy} - 1. \tag{25}
$$

The different behaviour of the two curves is due to the different definition of the Born cross section in both the schemes.

2. QED - corrections to the neutral current reaction

The photon bremsstrahlung due to diagrams (1c) is also treated in the quark-parton model:

$$
\sigma_{QED} = \sum_{a,A} \sigma_{QED}^{a}(A) \; ; \; a = \ell, i, q \; ; \; A = \gamma, I, Z.
$$

We make a twofold analytic integration over the photon angles using SCHOONSCHIP /20/. The last integration is performed numerically, folding in the parton distribution functions x.

The gauge-invariance and infrared finiteness are guaranteed separately for corrections to the electron legs ($a = e$), to the quark legs ($a = q$), and to their interference ($a = i$). They are also separately fulfilled for the photon exchange (A = γ),

x In fact, we neglect here the smooth Q^2-dependence of quark distributions. Nevertheless, the result remains very accurate for the corrections δ to be introduced below; see also the discussion in /10/.

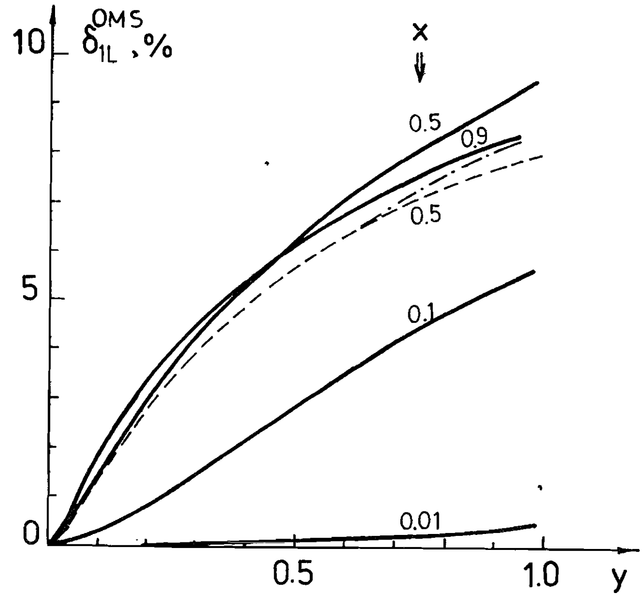

Fig.4a.

The one-loop correction δ_{1L} of (25) to the NC cross-section in the OMS (Fig.4a) and MOMS (Fig.4b) schemes; the linearized in α δ_{1L} (dashed-dotted line); the corresponding quantity taken from /7/ (dashed line). Parameters as in Fig.2.

Z-boson exchange (A=Z), and for their interference (A= I); for the last two items, independent vector and axial vector terms appear. In sum, one has to deal with 15 independent QED-corrections.

Till now, the three photon exchange contributions $\sigma_{QED}^{a}(\gamma)$ have been recalculated. As is to be expected, the $\sigma_{QED}^{e}(\gamma)$ depends only on the electron mass via $\ln(Q^2/m_e^2)$, the interference term $\sigma_{QED}^{i}(\gamma)$ is independent of any light fermion mass, whereas $\sigma_{QED}^{q}(\gamma)$ depends logarithmically on the quark mass parameters:

$$\frac{d^2\sigma_{QED}^{e}(\gamma)}{dx\,dy} = \frac{2\alpha^3 s Q_e^4 x}{Q^4}\sum_q Q_q^2\Big\{y_+\Big[\ln\frac{x_1^2 y^2}{x^2 y_1}\Big(\ln\frac{Q^2}{m_e^2}-1\Big)+\frac{3}{2}\ln\frac{Q^2}{m_e^2}$$

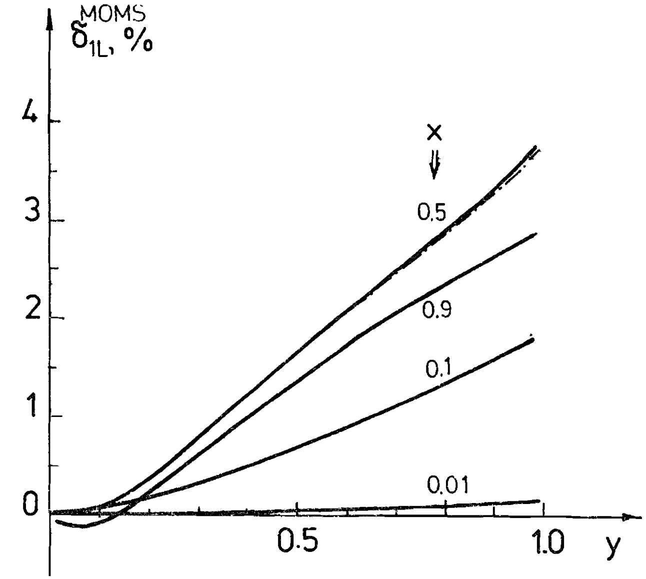

Fig.4b

$$-\frac{1}{2}\ln^2 y_1 - 2\Big] f_q(x,Q^2) + 2y_+\Big(\ln\frac{Q^2}{m_e^2}-1\Big)\int_1^{1/x} d\xi\,\frac{\xi f_q(x\xi,Q^2)-f_q(x,Q^2)}{\xi-1}$$

$$+y^2\int_1^{1/x}\frac{d\xi}{\xi}\,f_q(x\xi,Q^2)\Big[\varphi(1,y_1)+\varphi(-y_1,-1)\Big]\Big\}, \qquad (26)$$

with $\quad x_1 = 1-x,\ y_1 = 1-y,$

$$\varphi(a,b) = 1-\ln\frac{Q^2}{m_e^2} - \frac{y_+(\xi-1)}{2ab} + \frac{1}{2\xi}\ln\frac{Sy(\xi-1)}{M_p^2 x}$$

$$-\frac{y}{2(\xi a-y)}\ln\frac{Q^2(\xi a-y)^2}{m_e^2 y^2(\xi-1)} - \Big(a-\frac{y}{2\xi}-\xi\frac{y_+}{y}\Big)\frac{1}{b}\ln\frac{S^2 b^2}{m_e^2 M_p^2}, \qquad (27)$$

M_p being the proton mass.

$$
\frac{d^2\sigma^{i}_{QED}(\gamma)}{dx\,dy} = \frac{2\alpha^3 S Q_e^3 x}{Q^4} \sum_q Q_q^3 \Big\{ \Big[4y_+ \ln y_1 \ln\frac{x_1}{x} + y \ln y_1 - y_- \Big(\ln y \ln\frac{y}{y_1}
$$

$$
+ \frac{1}{2}\ln^2 y_1 + \ln y + \frac{1}{2}\pi^2 \Big) \Big] f_q(x,Q^2) + 4y_+ \ln y_1 \int_1^{1/x} d\xi \, \frac{f_q(x\cdot\xi, Q^2) - f_q(x,Q^2)}{\xi - 1} \tag{28}
$$

$$
+ \int_1^{1/x} d\xi\, f_q(x\cdot\xi, Q^2) \Big[-2\frac{y^2}{\xi^2} \ln y_1 + y_- \Big(\frac{y^2}{\xi_1 \xi_2} - \frac{2}{\xi^2} - \frac{2}{\xi}\ln(\xi-1) + \frac{1}{\xi-1} \ln\frac{\xi_1\xi_2}{y_1} \Big) \Big] \Big\},
$$

with $\xi_1 = \xi - y$, $\xi_2 = \xi y_1 + y$,

$$
\frac{d^2\sigma^{q}_{QED}(\gamma)}{dx\,dy} = \frac{2\alpha^3 S Q_e^2 x y_+}{Q^4} \sum_q Q_q^4 \Big\{ \Big[-\frac{5}{4} - \frac{\pi^2}{6} - \frac{7}{4}\ln\frac{x_1}{x} - \frac{1}{2}\ln^2\frac{x_1}{x} \tag{29}
$$

$$
+ \Big(\frac{3}{4} + \ln\frac{x_1}{x} \Big) \ln\frac{Q^2}{m_q^2} \Big] f_q(x,Q^2) + \int_1^{1/x} d\xi \, \frac{f_q(x\cdot\xi,Q^2) - f_q(x,Q^2)}{\xi - 1} \Big[\ln\frac{Q^2}{m_q^2(\xi-1)} - \frac{7}{4} \Big]
$$

$$
+ \int_1^{1/x} \frac{d\xi}{\xi} f_q(x\xi, Q^2) \Big[2 + \frac{1}{\xi}\Big(2\frac{y_1}{y_+} + \frac{1}{2} \Big) + \frac{2\xi\ln\xi}{\xi - 1} - \frac{1}{2}\Big(1 + \frac{1}{\xi}\Big) \ln\frac{Q^2\xi^2}{m_q^2(\xi-1)} \Big] \Big\}.
$$

* In our opinion, the best presentation for a comparison of QED corrections of different authors is to show them separately relative to the QED Born term:

$$
\delta^{a}_{QED}(A) = \frac{d^2\sigma^{a}_{QED}(A)}{dx\,dy} \Big/ \frac{d^2\sigma_B(\gamma)}{dx\,dy}. \tag{30}
$$

These corrections are presented in Figs.5a–c.

At the end of this section we only remark that in our naive approach the bremsstrahlung from quark legs σ^{q}_{QED} depends on quark masses which have no definite physical meaning. In principle, it is known how to cure this drawback by a redefinition of "bare" quark distributions at $Q^2 = Q_0^2$ /21/. Evidently, this point deserves further discussion to be presented elsewhere.

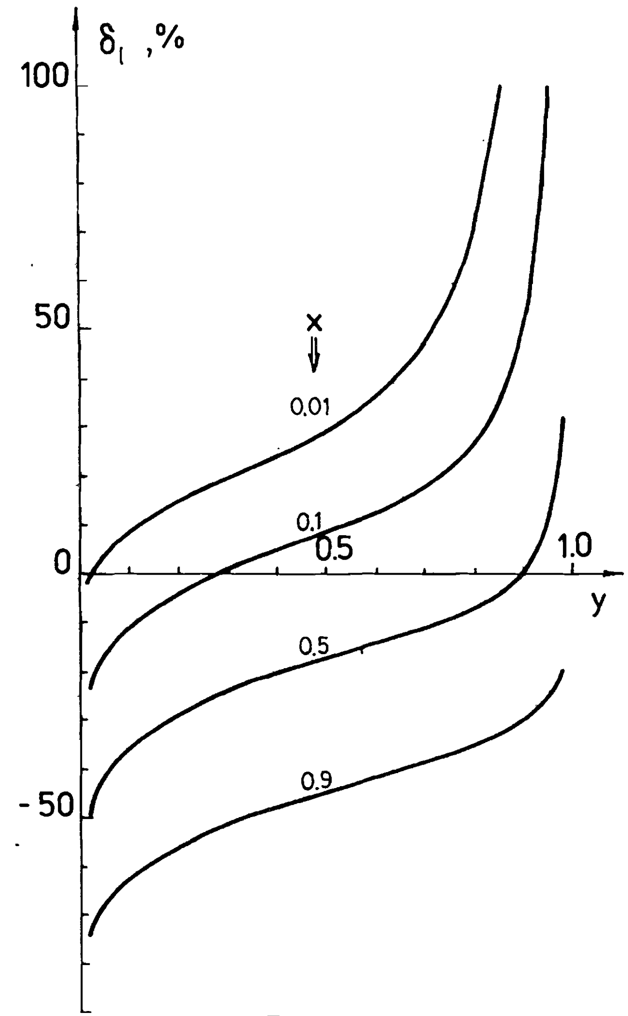

Fig.5a.

QED rad. corrs. (30) from photon exchange diagrams due to radiation from (a) lepton legs, (c) quark legs, (b) their interference. Parameters as in Fig.2.

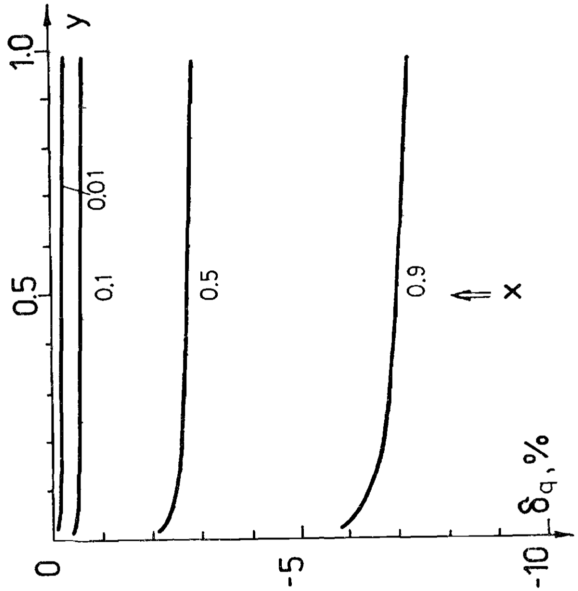

Fig. 5c

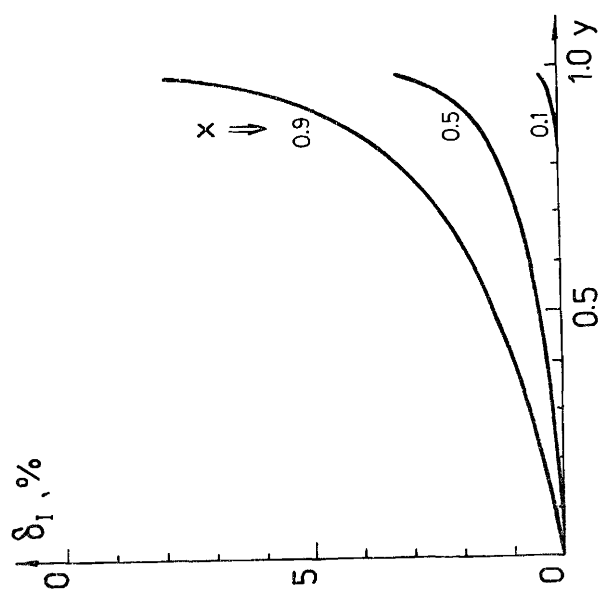

Fig.5b

3. Born cross section and one-loop corrections for the charged current reaction

Here we consider the cross section

$$\sigma_{cc} = \frac{d^2\sigma}{dx dy}\left[e^{\pm}(\lambda) p \longrightarrow \overset{(-)}{\nu}_e X(\gamma)\right]. \tag{31}$$

In analogy to the neutral current process, one would like to separate QED-contributions from genuine weak loop corrections. But a simple collection of diagrams with one additional (virtual or real) photon does not lead to a gauge-invariant expression. May be the simplest example of this well-known fact is W-decay /12/. Nevertheless, there is a unique possibility to separate what is mainly QED from weak loop corrections. We propose to consider as the QED-contribution the sum of bremsstrahlung σ_{cc}^{br} and those parts $\sigma_{cc}^{QED,1L}$ of the loops with an additional internal photon which are essentially connected with the IR-singularity: the IR-pole terms and all logarithmic mass singularities. The $\sigma_{cc}^{QED,1L}$ is well-defined up to a constant. If one uses at any place of arbitrariness one and only one dimensional parameter M_W as normalization, then the proposed separation is unique and evidently gauge-invariant:

$$\sigma_{cc} = \sigma_{cc}^{1L} + \sigma_{cc}^{QED}, \quad \sigma_{cc}^{QED} = \sigma_{cc}^{QED,1L} + \sigma_{cc}^{br}. \tag{32}$$

So far, we have calculated the one-loop corrections to the charged current reaction in the MOMS renormalization scheme:

$$\sigma_{cc}^{1L} \equiv \frac{d^2\sigma^{\pm}(\lambda)}{dx\,dy} = \frac{G_\mu^2 S}{\pi}\frac{1}{(1+Q^2/M_W^2)^2}\frac{1+Q_e\lambda}{2} \times \tag{33}$$

$$\times\left\{\sum_u \rho_c^2(S\cdot x, Q^2, Ux)\, x f_{\bar{u}(u)} + (1-y)^2 \sum_d \rho_c^2(U x, Q^2, S\cdot x)\, x f_{d(\bar{d})}\right\},$$

where again the connection with the OMS scheme may be expressed by the function δr:

$$\frac{G_\mu^2}{\pi} M_W^4 \rho_c^2 = 2\pi\alpha^2 \frac{1}{(2 s_W^2)^2} \mathcal{F}_c^2 = \frac{2}{\pi}\left(\frac{g}{8}\right)^2 \mathcal{F}_c^2, \tag{34}$$

$$\rho_c = (1-\delta r)\,\mathcal{F}_c$$

and $\mathcal{F}_c$ may be taken from /11,12/. In defining ρ_c and $\mathcal{F}_c$ we excluded the above-mentioned singular QED-terms:

$$\rho_c^{QED,1L}(S,Q^2,U) = \frac{\alpha}{4\pi}\left[2\cdot A(S,Q^2,U)\cdot P_{IR} + B\right],$$

$$A(s,Q^2,u)=Q_e^2+Q_d^2+Q_u^2+2|Q_uQ_d|\ln\frac{Q^2}{m_u m_d}-2|Q_eQ_u|\ln\frac{s}{m_e m_u}-2|Q_eQ_d|\ln\frac{|u|}{m_e m_d},$$

$$B=Q_e^2\ln\frac{m_e^2}{M_W^2}+Q_u^2\ln\frac{m_u^2}{M_W^2}+Q_d^2\ln\frac{m_d^2}{M_W^2}+b(e,u)+b(e,d)-b(u,d),\quad(35)$$

$$b(e,u)=|Q_eQ_u|\left(\frac{1}{2}\ln^2\frac{m_e^2}{M_W^2}+\frac{1}{2}\ln^2\frac{m_u^2}{M_W^2}-3\ln\frac{m_e m_u}{M_W^2}\right),$$

$$P_{IR}=\frac{1}{n-4}+\frac{1}{2}\gamma+\ln\frac{M_W}{2\sqrt{\pi}\mu}\equiv\ln\frac{M_W}{\lambda},\quad(36)$$

where λ is the finite, small photon mass used as IR-regulator by some authors.

The Born cross section in the MOMS renormalization scheme is shown in Fig.6 . In Fig.7 the corrections due to the weak-loop terms are shown both for the MOMS and OMS schemes. The δ_{1L} are defined in analogy to the neutral current case (eq. 25).

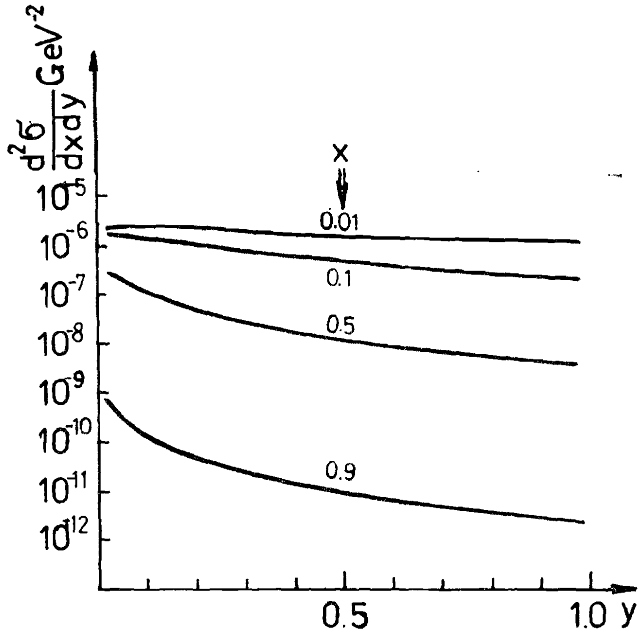

Fig.6.

Charged current cross-section in Born approximation in the MOMS scheme. Parameters as in Fig.2.

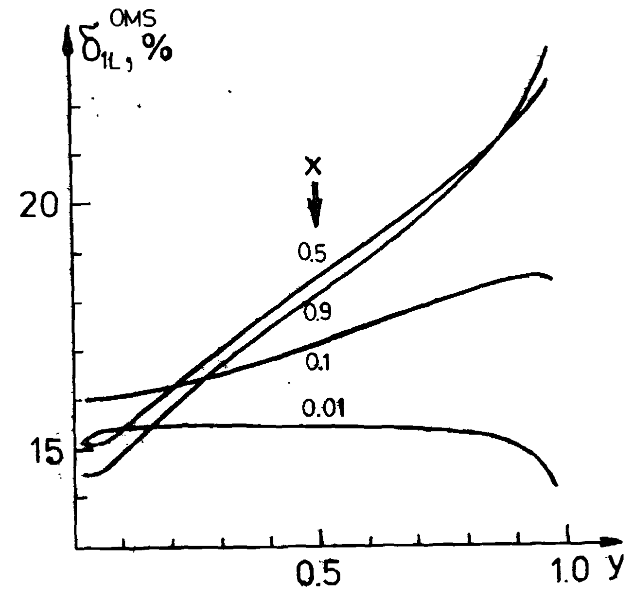

Fig.7a.

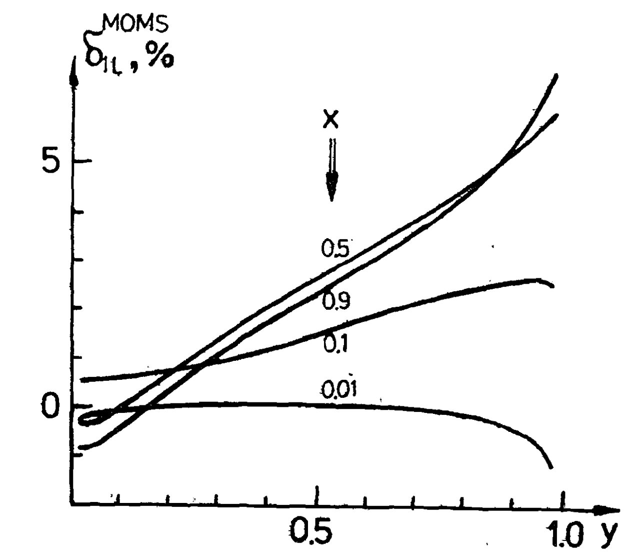

Fig.7b.

The loop correction δ_{1L} to the CC cross-section in the OMS (a) and MOMS (b) schemes. Parameters as in Fig.2.

4. Discussion

We have restricted this study to a careful presentation of intermediate results. Some formulae being dropped here together with the recalculation of massive gauge boson exchange bremsstrahlung will be published soon, with a greater emphasis on the physical contents.

Now, a few comments will be given on questions of the reliability and representation of EWRC.

1.

An interesting feature of the weak loop correction δ_{1L} of the NC-cross section may be observed in Fig.4. Figure 4a shows a rising with y (i.e. rising with Q^2 for fixed S and x) difference between our result and the corresponding one of /7/, both being calculated in the OMS scheme. In search for an explanation we linearized our eqs. (6-9) totally with respect to powers of α. As a consequence, our δ_{1L} is shifted towards that of /7/ and for $y \leq 0.8$ the agreement is very good. This shift is mainly due to large contributions from δr. In the MOMS scheme, instead, the cross section is completely stable against that linearization; see Fig.4b. The EWRC are smaller in that scheme since large corrections from δr are absorbed in G_μ. Taken these facts together we conclude that from the point of view of EWRC one should prefer the MOMS scheme. Further, we emphasize again that the form factor notation proposed here for ep-scattering is a quite natural generalization of Born formulae allowing a simple, gauge-invariant representation of the EWRC.

2.

Similar observations may be drawn for the CC loop corrections, Fig.7. The δ_{1L} is again much smaller in the MOMS scheme. From the explicit functional dependence one could expect a constant difference due to only $(1-\delta r)^2$ of the order of 14% and completely independent of the kinematics. But again this is true only up to terms linear in α, which explains that there is not simple a shift in scale between Figs.7a and 7b.

3.

The dominant and most rapidly varying bremsstrahlung contribution is due to the lepton leg as is seen from Fig.5. There are two reasons for this dominance. One is due to the small electron mass, leading to logarithms $\ln(Q^2/m_e^2)$ which cause large negative δ_ℓ-values. The other is of a kinematical origin. At large y the electron can loose a large part of its energy by hard photon radiation and afterwards may scatter at a lower average energy leading

to an enhanced cross-section and, finally, to large positive δ_ℓ-values. So, δ_ℓ varies with y (and x) very rapidly, a feature not being visible in the figures of /7/. Further, the δ_q is in our calculations about four times smaller in absolute values as that in /7/. At least at small Q^2 where photon exchange dominates the Z-exchange this is a discrepancy which should be studied further. We stress the importance of using identical quark distributions in programs to be compared, especially at small x. See also /21/. Or course, we have checked the stability of numerical integrations. Further, we proved the analytical agreement of eqs. (27-29) with formulae of a considerably more complexity published earlier /4/. Finally, there is a very good if not excellent numerical agreement of the QED corrections $\delta_{\ell,q}$ of Fig.5 with those obtained with TERAD86 if equal quark distributions are used. For δ_ℓ, the lepton leg correction, this is true too, although δ_ℓ in TERAD86 has been determined in an approach independent of any parton model approach.

In sum, we see no argument against the further use of ASYMETR till the availability of a more modern FORTRAN code, e.g. the DISEP under development at Dubna which is documented here to some extent.

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Бардин Д.Ю. и др. E2-87-595

Изучение электрослабых радиационных поправок для глубоконеупругого ep-рассеяния при энергиях ускорителя ГЕРА

Излагаются результаты нового детального исследования электрослабых радиационных поправок к глубоконеупругому ep-рассеянию в каналах нейтрального и заряженного токов при энергиях ускорителя ГЕРА. Численные результаты получены с использованием новой фортранной программы DISEP.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

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Bardin D.Yu. et al. E2-87-595

Study of Electroweak Radiative Corrections to Deep Inelastic Scattering at HERA

Results of a careful recalculation of electroweak radiative corrections to neutral and charged current deep inelastic ep-scattering at HERA energies are presented. Numerical results are based on the newly developed Fortran code DISEP.

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

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