VU VRIJE UNIVERSITEIT AMSTERDAM

VU Research Portal

Separated structure functions for the proton-knockout reaction^{16}O(e,e'p)

Blok, H.P.; de Witt Huberts, P.K.A.; Jans, E.; Lapikas, L.; Spaltro, C.M.; van der Schaar, M.; van der Steenhoven, G.

published in
Physical Review C
1993

document version
Publisher's PDF, also known as Version of record

Link to publication in VU Research Portal

citation for published version (APA)
Blok, H. P., de Witt Huberts, P. K. A., Jans, E., Lapikas, L., Spaltro, C. M., van der Schaar, M., & van der Steenhoven, G. (1993). Separated structure functions for the proton-knockout reaction^{16}O(e,e'p). *Physical Review C*, *48*(5), 2385-2389.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

E-mail address:
vuresearchportal.ub@vu.nl

Download date: 17. Jun. 2021

Separated structure functions for the proton-knockout reaction $^{16}O(e,e'p)$

C. M. Spaltro,[1,2,*] H. P. Blok,[1,3] E. Jans,[1] L. Lapikás,[1] M. van der Schaar,[2,†]
G. van der Steenhoven,[1] and P. K. A. de Witt Huberts[1,2]

[1]*Nationaal Instituut voor Kernfysica en Hoge-Energiefysica, P.O. Box 41882, 1009 DB Amsterdam, The Netherlands*
[2]*R. J. van de Graaff Laboratorium, Universiteit Utrecht, P.O. Box 80.000, 3508 TA Utrecht, The Netherlands*
[3]*Department of Physics and Astronomy, Vrije Universiteit, de Boelelaan 1081, 1081 HV Amsterdam, The Netherlands*

(Received 28 April 1993)

Three structure functions have been determined in the reaction $^{16}O(e,e'p)^{15}N$ at $Q^2 = 0.20$ (GeV/c)^2 for $1p_{1/2}$ and $1p_{3/2}$ knockout and for the excitation of the $(5/2^+, 1/2^+)$ doublet at $E_x = 5.3$ MeV in ^{15}N. The longitudinal-transverse interference structure function W_{LT} is enhanced by a factor $2.05 \pm 0.06 \pm 0.12$ for $1p_{3/2}$ knockout and by a factor $1.50 \pm 0.10 \pm 0.08$ for $1p_{1/2}$ knockout with respect to a calculation that gives a proper account of data taken in parallel kinematics. The longitudinal structure function W_L is also enhanced, albeit less with respect to these calculations.

PACS number(s): 25.30.Fj, 27.20.+n

Experiments involving the electron-induced proton-knockout reaction are commonly used to study proton momentum distributions in atomic nuclei [1, 2]. In most cases these experiments comprise cross-section measurements only. More information on various aspects of the $(e,e'p)$ reaction, such as the basic electron-proton coupling or the final-state interaction, can be obtained by studying the four structure functions that are contained in the $(e,e'p)$ cross section. By combining cross sections measured under different kinematical conditions one can isolate these structure functions, and thus reveal effects that may not be easily observable in the cross section. A few experiments involving a separation of the longitudinal and transverse structure functions have been performed in kinematics with the recoil proton and virtual-photon momentum vectors parallel [3]. For transitions to final states below the two-particle emission threshold these experiments generally confirm the validity of the impulse approximation. In this paper we present the results of an $(e,e'p)$ experiment on ^{16}O, in which all three in-plane structure functions have been measured. In previous $^{16}O(e,e'p)$ experiments [4, 5] not all in-plane structure functions have been extracted.

In the one-photon-exchange approximation the cross section for the $(e,e'p)$ reaction is expressed as follows [6]:

$$\frac{d^3\sigma}{de'd\Omega_{e'}d\Omega_p} = K\sigma_{\rm Mott}(v_L W_L + v_T W_T + v_{LT} W_{LT}\cos\phi + v_{TT} W_{TT}\cos 2\phi), \quad (1)$$

where W_L, W_T, W_{LT}, and W_{TT} represent the longitudinal, transverse, and interference structure functions, and the electron kinematical factors are given by $v_L = \frac{Q^4}{\mathbf{q}^4}$, $v_T = \tan^2\theta_e/2 - \frac{Q^2}{2\mathbf{q}^2}$, $v_{LT} = \frac{Q^2}{\mathbf{q}^2}\sqrt{\tan^2\theta_e/2 - \frac{Q^2}{\mathbf{q}^2}}$, and $v_{TT} = \frac{Q^2}{2\mathbf{q}^2}$, with θ_e the electron-scattering angle, $\mathbf{q}$ and ω the momentum and energy transfer, and $Q^2 = \omega^2 - \mathbf{q}^2$. In Eq. (1), $K = \frac{m_p \mathbf{p}'}{(2\pi)^3}$ is a kinematical factor and $\sigma_{\rm Mott}$ is the cross section for elastic scattering off a point charge. Finally, ϕ represents the angle between the electron-scattering plane and the plane defined by the momentum transfer $\mathbf{q}$ and the outgoing proton momentum $\mathbf{p}'$. If these planes coincide, the kinematics is labeled "in plane." The structure functions can be separated by performing measurements with different kinematical factors v and/or values of ϕ, while keeping $\mathbf{q}$ and ω constant. For the separation of W_{LT} in an in-plane experiment, two measurements at constant $\gamma = |\theta_{\mathbf{p}'} - \theta_{\mathbf{q}}|$ are required: one at $\theta_{\mathbf{p}'} < \theta_{\mathbf{q}}$ corresponding to $\phi = 0°$ and the other one at $\theta_{\mathbf{p}'} > \theta_{\mathbf{q}}$ corresponding to $\phi = 180°$, where $\theta_{\mathbf{p}'}$ ($\theta_{\mathbf{q}}$) is defined as the angle between the electron beam and $\mathbf{p}'$ ($\mathbf{q}$). For a separation of W_T and W_L an additional measurement at a different beam energy and scattering angle is needed at $\phi = 180°$. After subtracting the W_{LT} contribution from the cross section $W_L + \frac{\mathbf{q}^2}{2Q^2}W_{TT}$ and W_T can be determined. The contribution of W_{TT} cannot be separated from W_L with in-plane measurements only.

The experiment has been performed with the two high-resolution magnetic spectrometers at the medium-energy electron accelerator MEA of NIKHEF-K [7]. For the separation of structure functions one high (510.5 MeV) and three low (354.2, 304.3, and 301.2 MeV) beam energies were used with typical currents of 10 μA and a duty factor of about 1%. All data were obtained at momentum- and energy-transfer values, centered at $(|\mathbf{q}|, \omega) = (460$ MeV/c, 100 MeV), i.e., close to the cen-

*Present address: Department of Physics and Astronomy, Vrije Universiteit, Amsterdam, The Netherlands.
†Present address: KEMA NV, Utrechtseweg 310, Arnhem, The Netherlands.

 ©1993 The American Physical Society

ter of the quasielastic peak. The proton spectrometer was moved to five different positions at each side of $\mathbf{q}$ in order to cover a missing-momentum ($\mathbf{p}_m = \mathbf{q} - \mathbf{p}'$) range from 30 to 190 MeV/c. The missing-energy resolution was about 180 keV, which made it possible to resolve the $(5/2^+, 1/2^+)$ doublet at an excitation energy E_x= 5.3 MeV in ^{15}N from the $3/2^-$ state at E_x= 6.3 MeV.

A (heavy-water) waterfall target developed in Mainz [8] was used, in which the oxygen content represented a target thickness of typically 23 mg/cm^2, with an uncertainty of about 3%. Quasielastic $(e, e'p)$ data on both deuterium and oxygen were obtained simultaneously. For all details on calibration procedures, data analysis, and normalization factors we refer the reader to the published deuterium measurements [9].

In the present analysis the coincident events were kinematically reconstructed assuming knockout from the oxygen nucleus. Hence, the deuterium peak changes position with $\mathbf{p}_m$ in the missing-energy (E_m) spectrum due to improper calculation of the recoil energy. At some $(E_m, \mathbf{p}_m)$ combinations the two contributions overlap and a fitting procedure was used to separate them.

Because of the nonzero acceptance in angle and momentum of both spectrometers the kinematical factors in the cross-section expression, Eq. (1), show a significant variation within one measurement. A Monte Carlo simulation was performed in order to determine the weighted average values of the kinematical factors $K\sigma_{\rm Mott}$, v_L, v_T, v_{LT}, and v_{TT} for each $\mathbf{p}_m$ bin within one measurement. These average values were used to separate the structure functions. The same values were used in the calculation of the theoretical cross sections.

The measured values of $W_L + \frac{q^2}{2Q^2} W_{TT}$, W_T, and W_{LT} for the transitions to the $1/2^-$ and $3/2^-$ states, which are due to $1p_{1/2}$ and $1p_{3/2}$ knockout, and to the $(5/2^+, 1/2^+)$ doublet, which is assumed to correspond to $1d_{5/2}$ and $2s_{1/2}$ knockout, are displayed in Fig. 1. The measurements at the lowest $\mathbf{p}_m$ values were performed in parallel kinematics; i.e., the vectors $\mathbf{q}$ and $\mathbf{p}'$ have the same direction, causing W_L and W_T to contribute only (triangles in Fig. 1). Since W_L and W_T in parallel kinematics are different from the ones in nonparallel kinematics [as $W = W(Q^2, T_p, |\mathbf{p}_m|, \gamma)$], there are separate theoretical curves for the two cases.

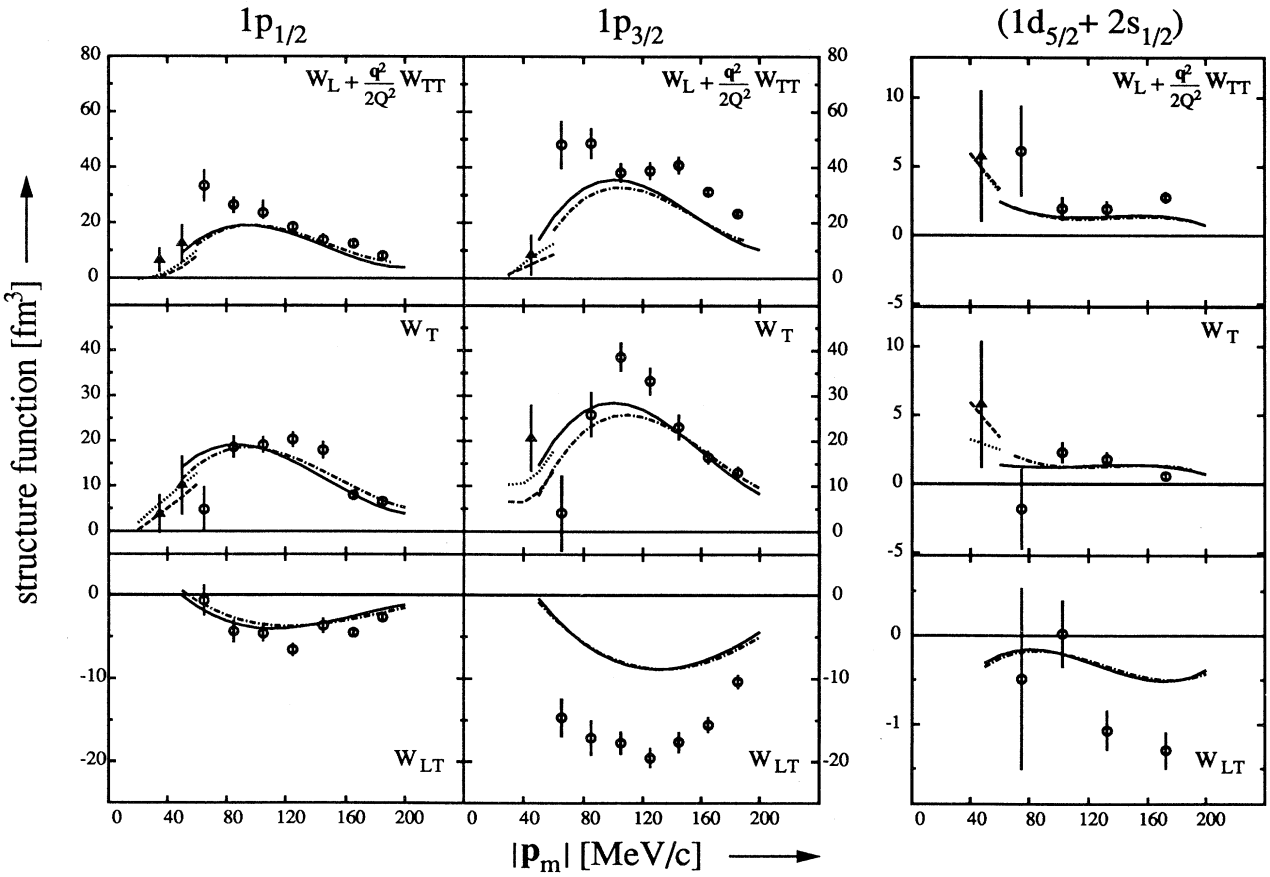

FIG. 1. Separated structure functions $W_L + \frac{q^2}{2Q^2} W_{TT}$, W_T, and W_{LT} as a function of the missing momentum $|\mathbf{p}_m|$ for the transitions to the $1/2^-$, $3/2^-$, and $(5/2^+, 1/2^+)$ states in ^{15}N. The bin width is 20 MeV/c for the $1/2^-$ and $3/2^-$ states, while for the $(5/2^+, 1/2^+)$ doublet the bin width ranges from 50 to 70 MeV/c. The solid and dotted curves represent the CDWIA calculations using the parameters of Schwandt *et al.* [12], while the dot-dashed and dashed curves have been evaluated employing the Raben parameters [13].

Only statistical uncertainties have been included in the error bars of the structure-function data. The systematical error was determined by studying the effects on the separated structure functions of various experimental uncertainties [10], such as those due to spectrometer angular settings, target thickness, and detection efficiency. The total systematical error in the structure functions has been calculated by means of a variational error calculation. The obtained values increase from 4.5% at low $\mathbf{p}_m$ to 7% at high $\mathbf{p}_m$ for W_{LT}, and from 4% to 5.5% for W_L and W_T. These uncertainties are considerably smaller than those quoted in Ref. [9] for the deuterium data obtained in the same experiment due to the less steep $\mathbf{p}_m$ dependence of the ^{16}O$(e,e'p)$ cross section.

The calculations displayed in Fig. 1 have been obtained with the complete distorted wave impulse approximation (CDWIA) formalism [11] for the $(e,e'p)$ cross section. In this formalism the current and charge operators are treated up to second order in q/m_p. The Coulomb distortions of the electrons are treated in the eikonal approach to second order in $Z\alpha$, and the final-state interaction between the outgoing proton and the residual nucleus is fully taken into account.

In order to investigate the sensitivity of the calculations to the description of the final-state interaction, two optical-potential parametrizations were used, one due to Schwandt *et al.* [12] and one due to Raben [13]. Since the parametrization of Schwandt *et al.* was determined from the analysis of polarized proton scattering off nuclei in the mass range between 24 and 208, we extrapolated the parameters down to $A = 15$. The Raben parametrization was obtained from the analysis of polarized proton scattering off ^{16}O at proton kinetic energies of 65 and 100 MeV. In contrast to the parametrization of Schwandt *et al.*, the parametrization of Raben contains an imaginary surface term and no imaginary spin-orbit term.

The spectroscopic factor S_α and the root-mean-square $r_{\rm rms}$ radius of the bound-state wave function were determined from a different set of ^{16}O$(e,e'p)$ data, taken in parallel kinematics at NIKHEF with $T_p = 90$ MeV [14]. These data enable the independent determination of the parameters $r_{\rm rms}$ and S_α. Hence, these values are entirely independent of W_{LT}, which does not contribute in parallel kinematics. The values of S_α and $r_{\rm rms}$ have been determined separately for both final-state-interaction parametrizations.

Figure 1 shows a striking disagreement between the CDWIA calculation for W_{LT} and the data for the $1p_{3/2}$ transition. A smaller disagreement is observed for its spin-orbit partner, the $1p_{1/2}$ transition. The transition to the doublet at E_x= 5.3 MeV shows a similar discrepancy for W_{LT} as the $1p_{3/2}$ transition in the $\mathbf{p}_m$ range 120–200 MeV/c, which is dominated by $1d_{5/2}$ knockout. For the transverse structure function W_T the calculations are globally consistent with the data for both spin-orbit partners. On the other hand, for $W_L + \frac{\mathbf{q}^2}{2Q^2} W_{TT}$ the calculations are systematically below the data for both spin-orbit partners. From the CDWIA calculations of Ref. [15] the W_{TT} contribution, which was included in the curves of Fig. 1, was estimated to constitute less than 2% of $W_L + \frac{\mathbf{q}^2}{2Q^2} W_{TT}$ for our kinematics. Therefore, the discrepancy is supposedly not due to W_{TT}. The calculated results for all structure functions are rather similar for both optical potentials. Hence, it is concluded that the observed discrepancies do not originate from the use of a particular optical-model potential.

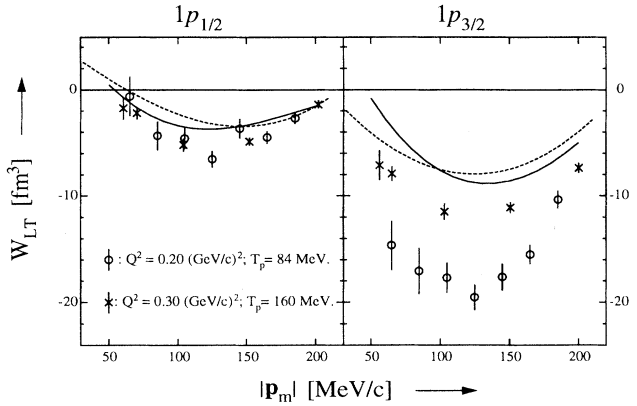

FIG. 2. Comparison of the W_{LT} data and the calculations for the present data (circles and solid curve) and those of Ref. [5] (crosses and dashed curve). Both calculations have been performed with the optical-potential parameters of Schwandt *et al.* and the same spectroscopic factors and rms radii (see Ref. [14]).

Results for W_{LT} in the reaction ^{16}O$(e,e'p)$ have also been obtained by Chinitz *et al.* [5]. Those data were taken at Saclay with an electron beam energy of E_e = 580 MeV, T_p = 160 MeV, $\mathbf{q}$ = 570 MeV/c, and ω = 170 MeV [i.e., Q^2 = 0.30 (GeV/c)^2]. As the missing-energy resolution was 1.3 MeV, the doublet at 5.3 MeV could not be resolved from the $3/2^-$ state at E_x = 6.3 MeV.

In Fig. 2 our data and those of Ref. [5] are compared to the results of calculations using the optical-model parameters of Schwandt *et al.* In order to make a consistent comparison, we used the bound-state wave function parameters ($r_{\rm rms}$ and S_α) employed in our analysis for calculations corresponding to the kinematics of Chinitz *et al.* There is a much larger discrepancy between our $1p_{3/2}$ data and the calculations than between the $1p_{3/2}$ data of Chinitz *et al.* and the calculations. The difference is even larger if one realizes that the Saclay results contain the unresolved contribution from the doublet to the $3/2^-$ transition, which we measured to be about 10%.

In order to give this comparison a more quantitative character we have evaluated the normalization factors needed to bring calculated structure functions (using S_α=1) in agreement with the data. If the CDWIA description was adequate, these normalization factors should be the same for all structure functions corresponding to the same transition, and could thus be identified as the spectroscopic factors S_α. The results are given in Table I. In the first three rows the values obtained from the present experiment are listed. In the fourth row the results of a reanalysis of the data of Chinitz *et al.* [5] using the same bound-state wave function and optical-model parametrization as in our analysis are shown. The results quoted in Ref. [5], using calculations of the type

TABLE I. Normalization factors derived from the present experiment and from the data of Ref. [5]. The results from the present analysis, a reanalysis of the data of Ref. [5] (fourth row) and the original results of Ref. [5] (fifth row) are listed. Both the statistical (first) and the systematical (second) errors are shown. For comparison we mention the spectroscopic factors deduced from the parallel-kinematics data of Ref. [14]: $S_{1p1/2} = 1.22 \pm 0.06$ and $S_{1p3/2} = 2.13 \pm 0.10$.

	$1p_{1/2}$	$1p_{3/2}$
$W_L^{\rm expt}/W_L^{\rm CDWIA}$	$1.60 \pm 0.06 \pm 0.07$	$3.19 \pm 0.11 \pm 0.15$
$W_T^{\rm expt}/W_T^{\rm CDWIA}$	$1.33 \pm 0.06 \pm 0.06$	$2.45 \pm 0.11 \pm 0.11$
$W_{LT}^{\rm expt}/W_{LT}^{\rm CDWIA}$	$1.83 \pm 0.15 \pm 0.11$	$4.36 \pm 0.22 \pm 0.26$
$W_{LT}^{[5]}/W_{LT}^{\rm CDWIA}$	$1.90 \pm 0.14 \pm 0.22$	$3.54 \pm 0.18 \pm 0.41$
$W_{LT}^{[5]}/W_{LT}^{\rm rel}$	$1.65 \pm 0.17 \pm 0.19$	$3.21 \pm 0.32 \pm 0.37$

presented in Ref. [6], are listed in the last row.

In all cases the normalization factor needed for W_{LT} is larger than the one obtained from either $W_L + \frac{\mathbf{q}^2}{2Q^2} W_{TT}$ or W_T. Compared to the spectroscopic factors measured in parallel kinematics [14] the present W_{LT} data for $1p_{3/2}$ ($1p_{1/2}$) knockout are enhanced by a factor $2.05 \pm 0.06 \pm 0.12$ ($1.50 \pm 0.10 \pm 0.08$). The W_{LT} results of the Saclay and NIKHEF experiments are consistent for $1p_{1/2}$ knockout, whereas for $1p_{3/2}$ knockout data the normalization factor is considerably larger in the present experiment.

Other experiments on ^{2}H [9] and ^{40}Ca [16] show a similar deviation of W_{LT} data with respect to nonrelativistic calculations. In the ^{2}H experiment the discrepancy for the W_{LT} results is largely solved if a fully relativistic calculation [17] is used. However, neither the relativistic calculations of Chinitz *et al.* (last row of Table I) nor relativistic calculations that have been carried out for our data [18] remove the discrepancy for W_{LT}. At present it is not understood why the deviation is much smaller for $1p_{1/2}$ knockout. The significantly smaller difference for the $1p_{3/2}$ data of Chinitz *et al.* [taken at $Q^2 = 0.30$ (GeV/c)^2 and $T_p = 160$ MeV] compared to our $1p_{3/2}$ data [taken at $Q^2 = 0.20$ (GeV/c)^2 and $T_p = 84$ MeV] might indicate a possible Q^2 and/or T_p dependence.

The $1p_{3/2}(1p_{1/2})$ normalization factors for $W_L + \frac{\mathbf{q}^2}{2Q^2} W_{TT}$ are enhanced by a factor $1.50 \pm 0.06 \pm 0.09$ ($1.31 \pm 0.06 \pm 0.08$) compared to the spectroscopic factors obtained in parallel kinematics. This effect might be caused by a large W_{TT} contribution, but this would be at variance with aforementioned CDWIA calculations [15], which predict a very small contribution of W_{TT}. Hence, the present ^{16}O$(e,e'p)$ data seem to indicate an enhancement of the ratio of longitudinal (L) and transverse (T) structure functions in nonparallel kinematics. This result does not have to be inconsistent with previous measurements of W_L/W_T ratios carried out in parallel kinematics, in which no discrepancies were found [3]. In the present experiment the γ dependence of the W_L/W_T ratio was measured while the existing parallel-kinematics data have been obtained for $\gamma = 0$. Apparently, the γ dependence of the W_L/W_T ratio is in disagreement with the CDWIA predictions.

Meson-exchange currents (MEC's) and isobar currents (IC's) could possibly be at the origin of the presently observed discrepancies for both W_{LT} and the W_L/W_T ratio. According to the simplified calculation for the reaction ^{16}O$(e,e'p)$ of Ref. [19] MEC and IC effects could result in an enhancement of both W_{LT} and the W_L/W_T ratio in nonparallel kinematics.

Recently, the effect of two-body currents on the $(e,e'p)$ structure functions was investigated in considerable detail by Van der Sluys, Ryckebusch, and Waroquier [20]. They performed a Hartree-Fock random phase approximation calculation in which two-body currents related to meson exchange and the excitation of the $\Delta(1232)$ resonance were included. Their calculation demonstrates that two-body currents explain part of the discrepancy between the W_{LT} data and the CDWIA calculation. Also, the effect of two-body currents is shown to be larger for $1p_{3/2}$ knockout than for $1p_{1/2}$ knockout. Further calculations are needed to verify whether MEC and IC effects are also able to explain the other structure functions and the data of Ref. [5].

In summary, we have presented results of a ^{16}O$(e,e'p)$ experiment in quasielastic kinematics in which we determined $W_L + \frac{\mathbf{q}^2}{2Q^2} W_{TT}$, W_T, and W_{LT} for $1p_{1/2}$ and $1p_{3/2}$ proton knockout, and for the transition to the $(5/2^+, 1/2^+)$ doublet at E_x= 5.3 MeV. The experimental data for W_{LT} show large deviations from the CDWIA calculations for all transitions including the doublet. The deviation is larger for the $1p_{3/2}$ case than for the $1p_{1/2}$ case. The results for W_T are well described by the calculations, whereas a significant enhancement of $W_L + \frac{\mathbf{q}^2}{2Q^2} W_{TT}$ was found. An analysis of a previous ^{16}O$(e,e'p)$ experiment [5] at a somewhat higher Q^2 and T_p reveals a similar but smaller discrepancy for W_{LT}. Recent calculations [20] suggest that the observed discrepancies are due to two-body currents.

We thank Dr. J. Friedrich for the use of the Mainz waterfall target, Dr. Y. Jin for his relativistic calculations, and Dr. M. B. Leuschner for letting us use his data prior to publication. This work is part of the research program of the National Institute for Nuclear and High-Energy Physics (NIKHEF-K), made possible by financial support from the Foundation for Fundamental Research on Matter (FOM) and the Netherlands Organisation for Scientific Research (NWO).

[1] S. Frullani and J. Mougey, Adv. Nucl. Phys. **14**, 1 (1984).
[2] P. K. A. de Witt Huberts, J. Phys. G **16**, 507 (1990).
[3] G. van der Steenhoven, Nucl. Phys. **A527**, 17c (1991).
[4] M. Bernheim *et al.*, Nucl. Phys. **A375**, 381 (1982).
[5] L. Chinitz *et al.*, Phys. Rev. Lett. **67**, 568 (1991).
[6] A. Picklesimer and J. W. Van Orden, Phys. Rev. C **40**, 290 (1989).
[7] C. de Vries , C. W. de Jager, L. Lapikás, G. Luijckx, R. Maas, H. de Vries, and P. K. A. de Witt Huberts, Nucl. Instrum. Methods **223**, 1 (1984).
[8] N. Voegler and J. Friedrich, Nucl. Instrum. Methods **198**, 293 (1982).
[9] M. van der Schaar *et al.*, Phys. Rev. Lett. **68**, 776 (1992).
[10] R. W. Lourie, in *Report of the 1987 Summer Study Group,* edited by F. Gross (CEBAF, Newport News, Virginia, 1988), p. 332.
[11] S. Boffi, C. Giusti, and F. D. Pacati, Phys. Rep. **226**, 1 (1993).
[12] P. Schwandt, H. O. Meyer, W. W. Jacobs, A. D. Bacher, S. E. Vigdor, M. D. Kaitchuck, and T. R. Donoghue, Phys. Rev. C **26**, 55 (1982).
[13] H. B. M. Raben (private communication).
[14] M. B. Leuschner, Ph.D. thesis, University of New Hampshire, 1992; M. B. Leuschner *et al.*, Phys. Rev. C (to be published).
[15] S. Boffi, C. Giusti, and F. D. Pacati, Nucl. Phys. **A386**, 599 (1982).
[16] H. J. Bulten, Ph.D. thesis, University of Utrecht, 1992; L. Lapikás, Nucl. Phys. **A553**, 297c (1993).
[17] E. Hummel and J. A. Tjon, Phys. Rev. Lett. **63**, 1788 (1989); Phys. Rev. C **42** 423 (1990).
[18] Yanhe Jin (private communication); Yanhe Jin, D. S. Onley, and L. E. Wright, Phys. Rev. C **45**, 1311 (1992).
[19] S. Boffi, C. Giusti, F. D. Pacati, and M. Radici, in *Proceedings CEBAF/SURA 1986 Summer Workshop,* edited by F. Gross (CEBAF, Newport News, Virginia, 1986), p. 133; INFN–Pavia Report No. FNT/T-86/01; S. Boffi and M. Radici, Nucl. Phys. **A526**, 602 (1991).
[20] V. Van der Sluys, J. Ryckebusch, and M. Waroquier, Phys. Rev. C (submitted).