Communications

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Cross sections for the reaction $^{16}O(\gamma, p_0)^{15}N$ at forward angles for $E_\gamma = 80$ MeV

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Via the reaction $^{16}O(e,p_0)^{15}N$ cross sections for the transition $^{16}O(\gamma,p_0)^{15}N$ have been extracted at angles $\theta_p = 5°-40°$. Whereas a modified quasideuteron model fails to describe the data, a calculation of Gari and Hebach with the inclusion of spin currents comes close to the results.

[NUCLEAR REACTIONS $^{16}O(e,p_0)^{15}N$, $E_e = 80$ MeV, measured $\sigma_e(E_e,\theta)$, deduced $\sigma_\gamma(E_\gamma,\theta)$; BeO target.]

In the last few years the reaction $^{16}O(\gamma,p_0)^{15}N$ has been investigated in the angular region $30° \leq \theta_p \leq 150°$ and in the energy region 60 MeV $\leq E_\gamma \leq 380$ MeV.[1,2] Since the first excited state of ^{15}N is separated from the ground state by $E_x = 5.27$ MeV the reaction can be investigated favorably with a bremsstrahlung beam in combination with a proton spectrometer of a resolution $\Delta E_p \ll E_x$. The cross sections measured are strongly peaked in the forward direction and decrease at first exponentially (starting at 60 MeV) with increasing photon energy. At an energy different for each proton angle the cross section flattens out. In a model in which the photon is absorbed by the protons, single particle momentum distributions[3] can be extracted from the cross sections. In the calculation of Londergan and Nixon[4] the production of the Δ isobar with the reabsorption of the pion in addition to the single particle contribution is responsible for the flattening out of the cross section. However, the observed neutron emission[5] with cross sections similar in size and shape could not be described by these models.

In other models the absorption of the photon takes place predominantly on correlated neutron-proton pairs,[6-8] and neutron emission is predicted in size and shape similar to those observed. In the quasideuteronlike picture of the absorption mechanism[8] the form factor $F(q)$ of the residual nucleus determines the shape of the cross section in a wide kinematical region. The change of the slope of the cross section is due to the first minimum and second maximum of $|F(q)|^2$ of the residual nucleus. An extension of the measurements of the cross sections to small forward angles is desirable for the following reasons. In the single particle model the contributions due to the spin current become important. The application of the modified quasideuteron model[8] requires the knowledge of the photodisintegration cross section of the deuteron, but especially at forward angles there has been up until now no agreement between different calculations and the measurements.[9]

In this paper we report a measurement of the reaction $^{16}O(e,p_0)^{15}N$ for proton angles of 5°, 10°, 15°, 20°, 30°, and 40°. Via the theory of virtual photon spectra the measured (e,p_0) cross sections have been converted to the corresponding (γ,p_0) cross sections. Close to the end point of the virtual photon spectrum the contributions from different multipolarities are to a first approximation (within the accuracy of the measurement) the same as in a real bremsstrahlung beam. The cross sections were determined relative to the (γ,p_0) cross sections measured by Findlay and Owens[1] at the angles $\theta_p = 30°$ and 45°.

The electron beam with a pulse width of 2.5 ns, a peak current of 200 mA, and a repetition rate of 300 Hz, momentum analyzed to $\Delta p/p = 0.2\%$, hits a target of BeO. At the small production angles the yoke of the magnetic spectrometer was in the beam line (Fig. 1), therefore the beam had to be dumped just behind the target in a block of graphite. In the focal plane (Fig. 2) the protons were analyzed

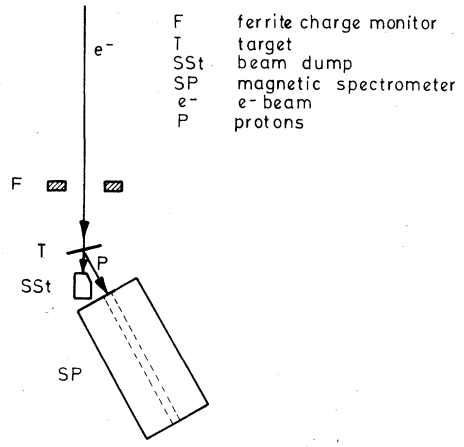


FIG. 1. Experimental setup (schematically).

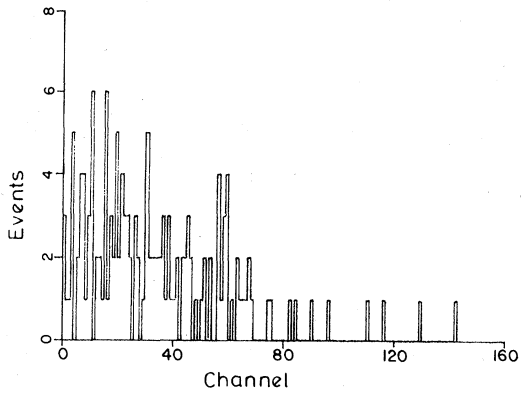
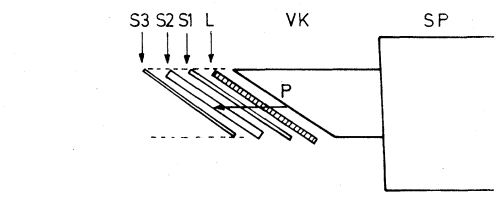


FIG. 3. Proton spectrum in the ladder hodoscope after off-line analysis. The kinematical end point due to the virtual photon spectrum is in channel 80.

by a ladder hodoscope consisting of 150 scintillators and identified with three additional scintillators as a backup array.

The detection system was connected via a CAMAC interface with a computer, which stored the data event by event on magnetic tape. An event consisted of the pulse height of each backup counter, the time of flight relative to a pickup signal from the accelerator, and the pattern of the hodoscope. In an off-line analysis the proton signals were identified due to the proper pulse heights and time of flight. The tremendous background, mainly produced in the beam dump close to the target, has been reduced to 10% in the worst case ($\theta_p = 5°$) (Fig. 3).

The results of our measurements are shown in Fig. 4. The error bars are statistical only. The full line represents a calculation by Hebach *et al.*[6] By inclusion of contributions from the spin current Gari and Hebach[10] improved their calculations (dotted line). These contributions become more important for higher photon energies in forward directions. The broken line is the result of a calculation with the modified quasideuteron model.



P proton
SP magnetic spectrometer
VK vacuum chamber
L ladder hodoscope
S 1,2,3 scintillators

FIG. 2. Focal plane detector system.

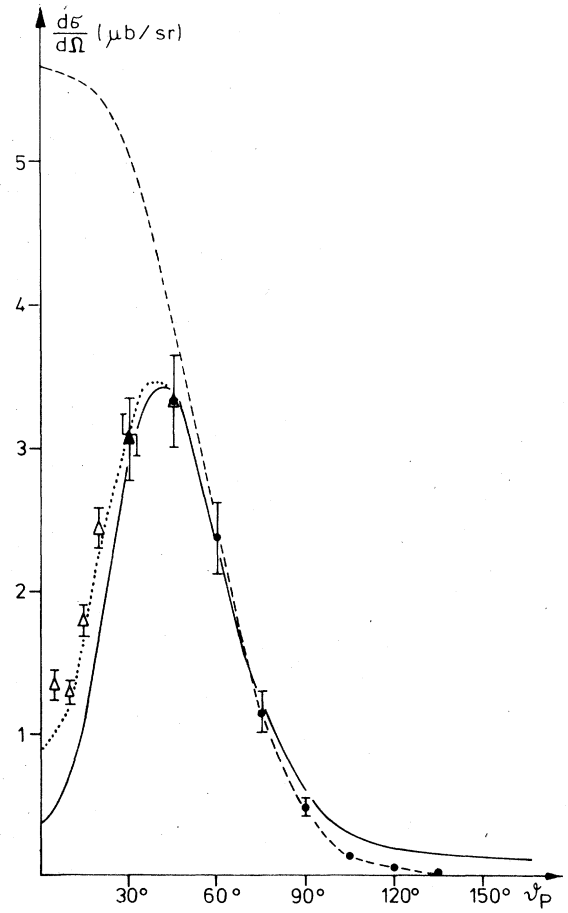


FIG. 4. Extracted cross sections (triangles) and the data from Glasgow (full circles). The calculations of Gari and Hebach without (full line) and with (dotted line) spin current contributions, and modified quasideuteron model (broken line).

This is the first case for (γ,p) and (γ,n) reactions leading to the ground state or first excited states [which have been measured for (γ,n) recently too] where this model[8] makes qualitatively wrong predictions. In the photodisintegration of the deuteron in the forward direction the D admixture in the deuteron wave function dominates the cross section. This cross section is also one of the ingredients in the modified quasideuteron model. There is no reason, however, to believe that correlated $(n\text{-}p)$ pairs in complex nuclei behave in these fine details of the wave function in the same way as in the deuteron. Therefore the failure of the modified quasideuteron model in predicting the cross section at these small forward angles is not a surprise.

These measurements have shown again that by choosing proper kinematical conditions certain quite interesting aspects of a reaction mechanism can be projected.

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