

different. The two 1^+ transitions both involve spin-transfer, while the 0^+ transition cannot. The low-lying 0^+ , IAS and 1^+ , 2.52 MeV states are expected to be predominantly $(f_{7/2}, f_{7/2}^{-1})$, whereas the 1^+ , 16.8 MeV state is expected to be predominantly $(f_{5/2}, f_{7/2}^{-1})$. Hence, the observed shapes indicate that the analyzing power is more sensitive to the nuclear structure involved than to whether or not spin-transfer is involved.

- 1) J. Raynal and R. Schaeffer, computer code DWBA70.
- 2) P. Schwandt et al., Phys. Rev. C 26, 55 (1982).
- 3) W.G. Love and M.A. Franey, Phys. Rev. C 24, 1073 (1981).
- 4) B.A. Brown, Michigan State University, private communication.

THE 0^+ TO 0^- TRANSITION IN THE $^{16}\text{O}(p,n)^{16}\text{F}$ REACTION AT 80 MeV

R. Madey, B.S. Flanders, B.D. Anderson, A.R. Baldwin, T. Chittrakarn, W. Pairsuwan, and J.W. Watson
Kent State University, Kent, Ohio 44242

J.J. Kelly
University of Maryland, College Park, Maryland 20742

W. Bertozzi, J.M. Finn and C.E. Hyde-Wright
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

C.C. Foster
Indiana University Cyclotron Facility, Bloomington, Indiana 47405

J.R. Comfort
Arizona State University, Tucson, Arizona 84721

H. Orihara
Tohoku University, Sendai 980, Japan

We measured the differential cross sections of the 0^- , 1^- , 2^- and 3^- states in ^{16}F from the $^{16}\text{O}(p,n)^{16}\text{F}$ reaction at an incident proton energy of 80 MeV. We achieved an energy resolution of 140 keV for 63 MeV neutrons with a flight path of 131 m and a Mylar ($\text{C}_{10}\text{H}_8\text{O}_4$) target of 10.8 mg/cm^2 . We measured time-of-flight spectra at 12 laboratory angles between 0 and 63 degrees (corresponding to momentum transfers from 0.22 to 1.93 fm^{-1}). Neutron detector arrays were installed in three detector stations at 0, 24 and 45 degrees with respect to the undeflected proton beam at distances of 131.0 m, 133.3 m and 131.1 m, respectively, from the target. The arrays consisted of NE-102 plastic

scintillators 0.102 m thick with frontal areas of 1.55 m^2 , 1.55 m^2 and 2.32 m^2 , respectively. The performance of the large-volume, mean-timed, neutron detectors was reported previously.¹ Thin (0.953 and 1.27 cm thick) plastic scintillation counters were placed in front, behind, above and below the neutron detectors to veto cosmic rays. Between each neutron detector and the rear anticoincidence detector was material to stop recoil protons from neutron interactions in the rear of the neutron detector. Lexan, 3.8 cm thick, was used for this purpose in the 0 and 24 degree stations; 15 cm of plywood was used in the 45 degree station. In order to be able to

calculate reliably the neutron detection efficiency, the pulse-height response of each detector was obtained with a ^{228}Th radioactive gamma source. The efficiency was checked (to an accuracy of $\sim 10\%$) by verifying that the 0° cross section for the $^{12}\text{C}(p,n)^{12}\text{N}$ (g.s.) reaction was consistent with our earlier measurements at 62, 99, 120, 135 and 160 MeV. This cross section served also to normalize the weaker yields from the states in ^{16}F . The counting rate from the ^{12}N ground-state peak provided also an on-line monitor for radiation damage to the Mylar target.

Figure 1 is a spectrum observed at a laboratory angle of 0 degrees. The yield of each of the four low-lying states in ^{16}F as well as the ^{12}N ground state was extracted on-line with the use of a peak-fitting code which generated the peak shape from the ^{12}N g.s. peak and fixed the excitation energies to their known values. The solid lines in Fig. 1 represent the

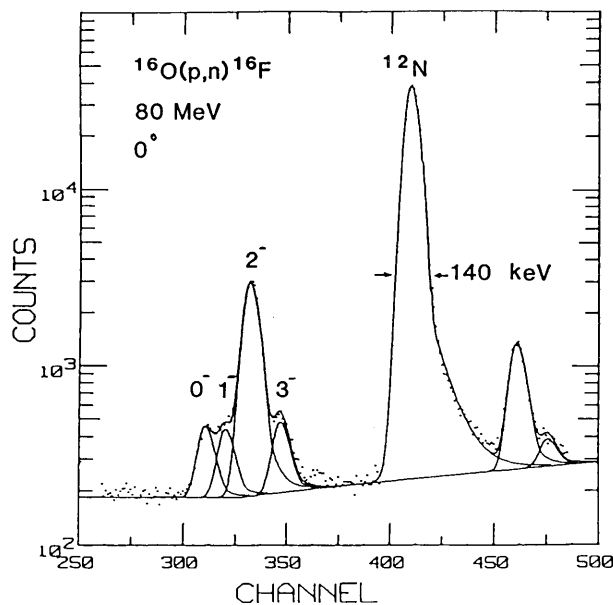


Figure 1. Neutron time-of-flight spectrum from the $^{16}\text{O}(p,n)^{16}\text{F}$ reaction at 80 MeV and a laboratory angle of 0° . The solid lines were generated with a peak-fit code.

results of a fit to this spectrum made with the code ALLFIT. In March of 1983, we carried out a short (five shift) feasibility study for this experiment (E204).² Figure 2 is a time-of-flight spectrum from this earlier study observed at a laboratory angle of 8 degrees, with a representative fit overlaid. (The code ALLFIT reverses the direction of excitation energy in Fig. 1 relative to Fig. 2.) The large amount of background from "overlap" observed in this spectrum produced a signal to background ratio of ~ 1.5 for the 0^- state. For the new measurements, the stripper loop was employed to allow a pulse selection of 1 in 72, increased from 1 in 6, which completely eliminated the overlap background, but reduced the time-averaged beam current from 200 nanoamps to about 80 nanoamps. The background now present is from cosmic rays (formerly $\sim 30\%$ of the total) and from the continuum of the

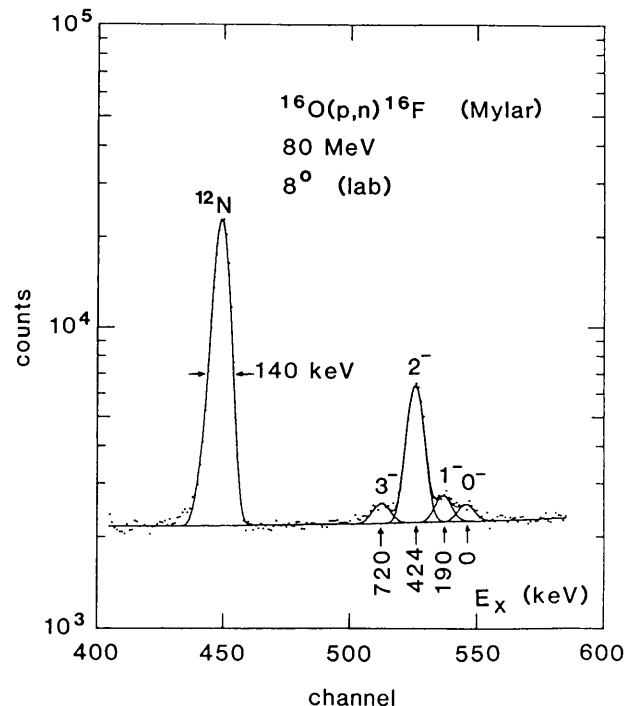


Figure 2. Neutron time-of-flight spectrum from the $^{16}\text{O}(p,n)^{16}\text{F}$ reaction at 80 MeV and a laboratory angle of 8° . The solid lines were generated with a peak-fit code.

$^{13}\text{C}(p,n)^{13}\text{N}$ reaction from the small amount of ^{13}C in the target. The signal-to-background ratio for the 0^- state was increased to ~ 4.1 in the new measurements. Also, the lower background allowed us to increase our neutron detection efficiency by using lower pulse-height thresholds.

In Figs. 3 and 4, we present the preliminary momentum-transfer distributions of the differential cross section, in the center of mass frame, calculated from the yields extracted "on-line" for each of the four ^{16}F states. The solid lines represent distorted-wave-impulse-approximation (DWIA) calculations performed with the shell-model wave functions of Donnelly and Walker,³ the optical-model parameters of Kelly,⁴ and (1) the effective interaction of Love and Franey,⁵ or (2) the M3Y effective interaction of Bertsch et al.⁶ The normalizations for the 0^- , 1^- , 2^-

and 3^- states in ^{16}F are 1.0, 0.18, 0.50 and 0.80, respectively, for the calculations with Love and Franey interaction and 0.15, 0.10, 0.25 and 0.50 for those with the M3Y interaction.

The isovector 0^- transition was observed also with $^{16}\text{O}(p,n)$ measurements,⁷ performed at 35 MeV, that covered a range of momentum transfers q from 0.24 to 2.0 fm^{-1} . The measured (p,n) cross section for the 0^- state exceeded DWIA calculations at $q > 1.4\text{ fm}^{-1}$. The disagreement was attributed to the effects of the pion field in nuclei. The differential cross section and the analyzing power of both the isovector and isoscalar 0^+ to 0^- transitions induced by the $^{16}\text{O}(p,p')$ reaction⁸ with 65 MeV polarized protons were measured over the momentum-transfer range 0.3 to 1.6 fm^{-1} . In this measurement, the large momentum-transfer

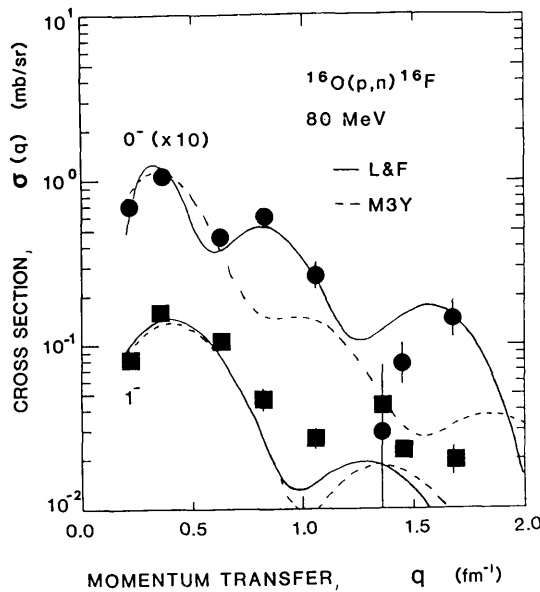


Figure 3. The differential cross section in the center-of-mass system versus the momentum transfer for the transitions to the 0^- and 1^- states in ^{16}F . The curves are DWIA calculations with the effective interactions of Love and Franey (solid) and Bertsch (dashed) as described in the text.

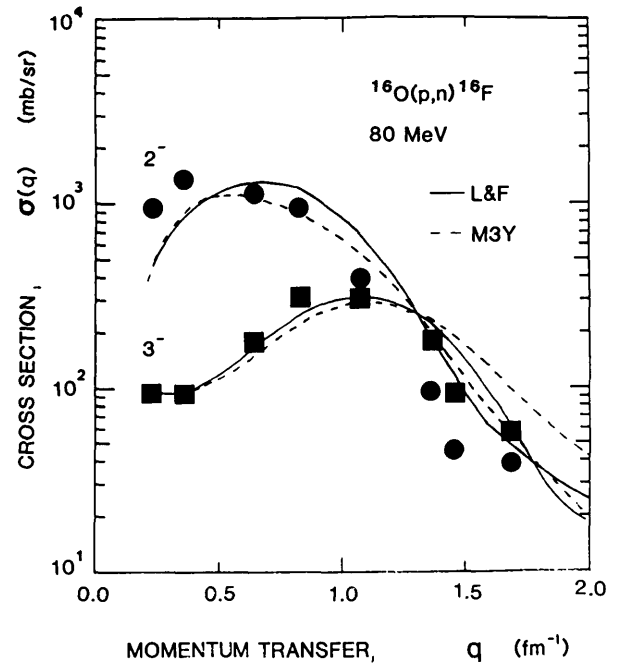


Figure 4. The differential cross section in the center-of-mass system versus the momentum transfer for the transitions to the 2^- and 3^- states in ^{16}F . The curves are DWIA calculations with the effective interactions of Love and Franey (solid) and Bertsch (dashed) as described in the text.

discrepancy between the calculated and measured cross sections for the isovector transition was not observed. The origin of the differences between these results appears to be in the reaction mechanism. Our measurements show a large-momentum transfer disagreement with the calculations performed with the M3Y effective interaction but not with those performed with the Love and Franey interaction.

1) R. Madey et al., Nucl. Instrum. and Meth. 214, 401 (1983).

- 2) IUCF Scientific and Technical Report, 1983, p. 35.
- 3) T.W. Donnelly and G.E. Walker, Ann. of Phys. 60, 209 (1970).
- 4) J.J. Kelly, Ph.D. Dissertation, M.I.T. (1981). (unpublished).
- 5) W.G. Love and M.A. Franey, Phys. Rev. C 25, 1073 (1981).
- 6) G. Bertsch, J. Barysowicz, H. McManus and W.G. Love, Nucl. Phys. A284, 399 (1977).
- 7) H. Orihara et al., Phys. Rev. Lett. 49, 1318 (1982).
- 8) K. Hosono et al., Phys. Rev. C 30, 746 (1984).

POLARIZATION-TRANSFER IN (p,n) REACTIONS

J.W. Watson, B.D. Anderson, A.R. Baldwin, T. Chittrakarn, B.S. Flanders and R. Madey
Kent State University, Kent, Ohio 44242

P.J. Pella
Hendrix College, Conway, Arkansas 72032

C.C. Foster
Indiana University Cyclotron Facility, Bloomington, Indiana 47405

I. van Heerden
University of the Western Cape, South Africa

One of the most interesting developments in the past half-dozen years in nuclear physics has been the realization that spin-flip modes of excitation become very important at medium energies, especially for isovector excitations. Perhaps the most direct method for studying such excitations is a polarization-transfer measurement. To this end, we began a program of (p,n) polarization-transfer measurements about a year ago with a study of the ${}^{40,48}\text{Ca}(p,n){}^{40,48}\text{Sc}$ reactions at 135 MeV.

Cornelius et al.¹ showed that under two simple assumptions (viz. central forces, and a single L-transfer) that spin-flip probabilities, which we will call "S", take on simple, characteristic values. Some of these values are listed in Table 1 for transitions

on even-even ($J^\pi=0^+$) targets. These values for the spin-flip probability "S" are combinations of Clebsch-Gordan coefficients for the angular momentum couplings for the final states. Note that with the exception of the $0^+ \rightarrow 0^-$ transition, all transitions with $\Delta S=1$ have spin-flip probabilities between 1/2 and 3/4. In general, the larger the spin, the closer "S" will be to 3/4. Thus, polarization-transfer measurements are most useful for low values of ΔL where the differences in "S" for different transitions are more pronounced. Polarization-transfer measurements to determine spin-flip probabilities are thus complementary to analyzing-power measurements: polarization-transfer is most useful near 0° where $\Delta L=0$ and $\Delta L=1$ dominate; analyzing powers must vanish identically at 0° .