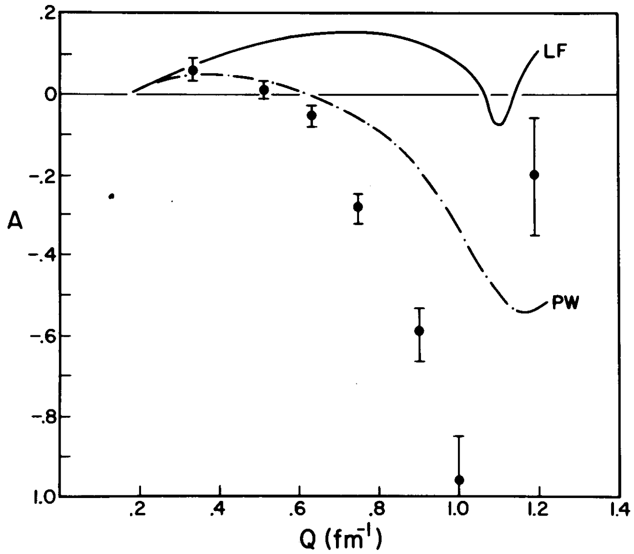

Figure 1. The $^{12}C(\vec{p},n)$ asymmetry at E_p = 160 MeV as a function of momentum transfer. The curve labeled L-F is the prediction of the Love-Franey[1] 140 MeV t-matrix. The curve labeled PW is the prediction of the Picklesimer-Walker[2] t-matrix.

is continuing on the $^{13}C(\vec{p},n)$ and $^{14}C(\vec{p},n)$ asymmetries and the results will be compared to the predictions of the distorted-wave impulse approximation.

1) W.G. Love, private communication.

2) A. Pickesimer and G. Walker, Phys. Rev. C12, 237 (1978).

THE (p,n) REACTION AT INTERMEDIATE ENERGIES WITH THE ISOTOPES OF OXYGEN (^{16,17} ^{18}O) AND ^{9}Be AS PART OF A UNIFIED APPROACH TO THE STUDY OF THESE NUCLEI

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Neutron energy spectra were measured and angular distributions extracted for various final states for the $^{16}O(p,n)^{16}F$ reaction at 99.1 MeV and for the $^{16,17,18}O(p,n)^{16,17,18}F$ and $^{9}Be(p,n)^{9}B$ reactions at 135 MeV. The neutron energy spectra at four angles are shown in Fig. 1 for the $^{16}O(p,n)^{16}F$ reaction at 99.1 and 135 MeV (plotted as excitation energy in the residual nucleus). The measurements were performed with a BeO target; the 135 MeV results include a $^{9}Be(p,n)^{9}B$ subtraction (channel-by-channel in the time-of-flight spectra). Angular distributions for eleven states in ^{16}F were extracted and compared with DWBA calculations in order to determine the ℓ-transfers for the transitions. In Table 1, we compare our results to levels known from the compilation of Ajzenberg-Selove[1] and also to shell-model predictions of Picklesimer and Walker.[2] The shell model predictions were used in a PWIA calculation[2] with an effective interaction based

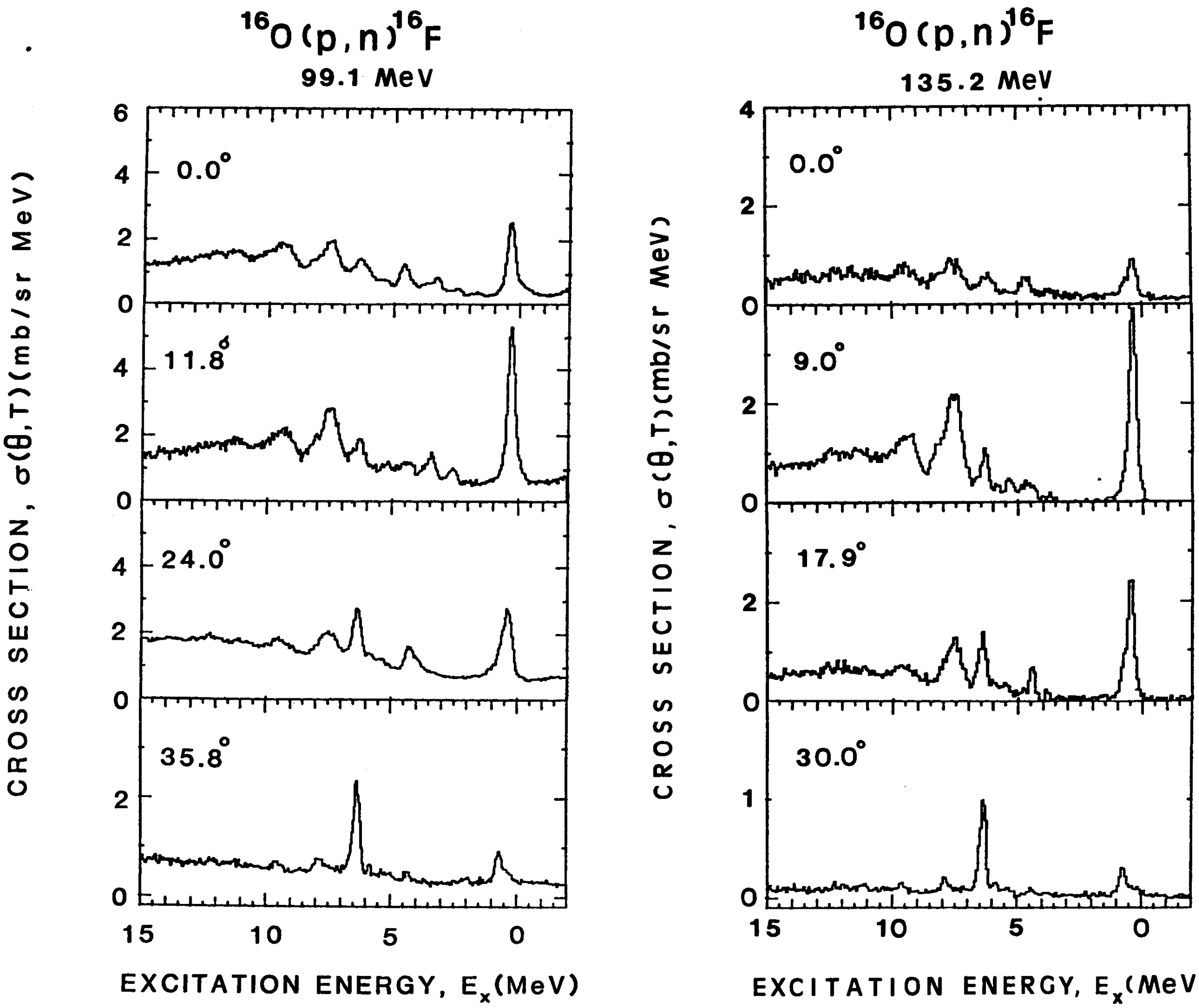

Figure 1. Neutron energy spectra from the $^{16}O(p,n)^{16}F$ reaction at (a) 99.1 MeV and (b) 135.2 MeV.

on free nucleon-nucleon scattering parameters in order to predict the angular distributions and relative strengths of the various states. Picklesimer and Walker predict that five states (2^-, 3^-, 3^+, 4^-, 2^-) are strongly excited. We observe each of these states. Note that these states include the 4^- "stretched" state at E_x = 6.37 MeV. Previously,[3)] we presented the angular distribution for this state as obtained from the 99.1 MeV experiment.

We note that the 2^- states predicted by Picklesimer and Walker include the giant magnetic quadrupole (M2) strength. The excitation energy of 7.6 MeV for the strongly excited state with a $\Delta\ell$ = 1 angular distribution agrees with the shell-model prediction of 7.4 MeV and with the observation by Sick et al.[4)] of 20.4 MeV for the giant M2 resonance in $^{16}O(e,e')$. (Excitation energies in ^{16}F are about 12.6 MeV lower than in ^{16}O as seen by the known excitation energies of the T = 1, 4^- stretched state of 18.98 and 6.37 MeV in ^{16}O and ^{16}F, respectively.)

In addition to the strongly excited states predicted by Picklesimer and Walker, we see also

Table 1. Energy Levels of ^{16}F

Compilation[1] E_x	Compilation[1] J^π	Picklesimer & Walker[2] E_x	Picklesimer & Walker[2] J^π	$^{16}O(p,n)^{16}F$ KSU-IUCF E_x	$^{16}O(p,n)^{16}F$ KSU-IUCF $\Delta\ell$	Tentative Assignment
0	$(1)^-$	0.0	2^-			
0.19	(0)	0.0	3^-			
0.42	(2)-			0.4	1	2^-
0.72	$(3)^-$	0.7	1^-	0.7	2 or 3	3^-
3.76	1^+			3.76	0	1^+
3.87	$(2)^+$					
4.37				4.35	2	3^+
4.65	1^+			4.65	0	1^+
4.97						
		5.0	3^+			
5.26						
5.39						
5.45						
5.53						
5.84						
				5.93	3	4^-
6.23				6.23	0	1^+
6.37		6.4	4^-	6.37	3	4^-
6.68						
7.11						
		7.4	2^-	7.6	1	2^-
7.73						
				9.4	1	1^-
				11.5	1	1^-

three states with $\Delta\ell = 0$ at E_x = 3.76, 4.65, and 6.23 MeV. These states are identified to be the analogs of the three M1 (1^+) states seen in $^{16}O(e,e')$ at E_x = 16.22, 17.14, and 18.80 MeV by Friebel et al.[5] Since M1 transitions would not be possible for a perfect closed-shell ^{16}O nucleus, the observations of the M1 states provide direct evidence of ground-state correlations.

We identify also states at E_x = 9.4 and 11.5 MeV to be analogs of the known[1] giant dipole resonance (GDR) in ^{16}O seen with two major components at 22 and 24 MeV. Because the $^{16}O(p,n)^{16}F$ energy spectra agree well in shape with photonuclear cross section excitation functions of the GDR in ^{16}O, we identify these states to be predominatly E1 with $J^\pi = 1^-$.

Finally, we note that we see a weakly-excited state at E_x = 5.93 MeV with an angular distribution similar to that observed for the strong 4^- state at 6.37 MeV. This state is likely the analog of the state recently seen[6] at E_x = 18.6 MeV in ^{16}O by (e,e') scattering and tentatively identified to have $J^\pi = 4^-$ also. Since this state is excited with only about 8% of the strength of the 4^- stretched state, this state likely has a small 1p-1h component.

The fact that comparisons between results seen in $^{16}O(e,e')^{16}O$ and $^{16}O(p,n)^{16}F$ are remarkably good is evidence that the (p,n) reaction at intermediate energies predominantly excites states with a one-step reaction mechanism. Additional evidence comes from the fact that all of the states seen in ^{16}F via the (p,n) reaction are either predicted by a simple shell-model calculation or are the analogs of known giant resonances (M1, M2, or E1 states) in ^{16}O.

The measurements performed for the $^{17}O(p,n)^{17}F$ and $^{18}O(p,n)^{18}F$ reactions at 135 MeV are being analyzed. Preliminary (on-line) results show that the $^{17}O(p,n)^{17}F$ (g.s) reaction, which is the analog-state transition, can be followed out to about 60°. The angular distribution reveals regions characterized by the ΔJ = 1, 3 and 5 parts of the transition. The $^{18}O(p,n)^{18}F$ spectra reveal considerable M1 strength at forward angles and a 5^+ stretched state of the $0\hbar\omega$ type[7] at wide angles.

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2) A. Picklesimer and G.E. Walker, Phys. Rev. C17, 237 (1978).

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ANALYZING POWER MEASUREMENTS FOR ($\vec{p}$,n) REACTIONS

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The first measurements of neutron analyzing powers were performed in November 1980 with 135 MeV polarized protons incident on a $^{9}Be^{16}O$ target. These measurements are part of a planned series of experiments to study analyzing powers from the ($\vec{p}$,n) reaction at intermediate energies. The neutron detectors in the 0°, 24°, and 45° stations each consisted of two neutron counters with combined frontal areas of 0.5, 1.0, and 1.5 m^2, respectively. Intermediate angles and angles out to 69° were obtained by deflecting the incident proton beam at the target with the beam-swinger facility. The neutron flight-paths were 90.9, 90.8, and 74.4 m, respectively. The energy resolution for 115 MeV neutrons was about 320 keV for the detectors in the 0° and 24° stations and about 415 keV for the detector in the 45° station.

On-line (preliminary) results for the $^{16}O(\vec{p},n)^{16}F$ (4^-;6.37 MeV) reaction are presented in Fig. 1. This (T = 1)4^- state is the analog of the known[1] 4^- state at E_x = 18.98 MeV in ^{16}O. The final state is a so-called "stretched" state believed[2] to be dominated by the simple one-particle, one-hole configuration ($\pi d_{5/2}$, $\nu d^{-1}_{3/2}$). The analyzing power

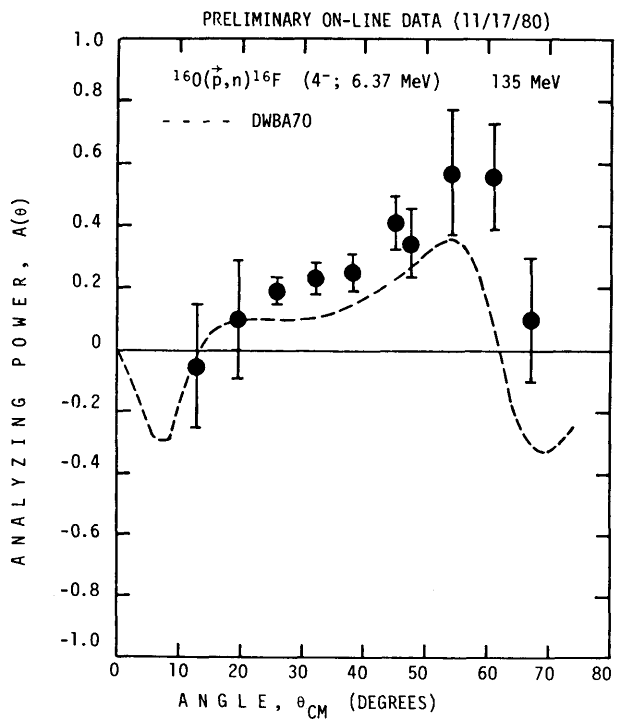

Figure 1. Angular distribution of the analyzing power for the $^{16}O(\vec{p},n)^{16}F$ (4^-; 6.37 MeV) reaction at 135 MeV. The dashed line is a DWBA70 calculation with the effective interaction of Love (1980).

for such an unnatural-parity, stretched-state transition is sensitive to the interference between three terms in the nucleon-nucleon effective interaction, viz., the isovector tensor term, the isovector