lines, which were calculated with a coupling constant 45% larger than that used for the solid lines. Medium modifications of the πNN coupling constant are implied by some interpretations of the EMC effect.

We feel that we have, at last, a reliable code that includes the most important physics of the (p,π) reaction in the near-threshold region. In addition to investigating the questions mentioned above, we hope to apply the model in the near future to the (p,π^-) reaction (for which only the two-nucleon mechanism contributes) and to other (p,π^+) reactions, and to extend the model to higher energies for interpretation of TRIUMF and future Cooler experiments. Finally, it is planned to document the code and to make it as user friendly as possible, so that it will be useful to the scientific community at large.

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STUDY OF HIGH-SPIN STATES AND THREE-QUASIPARTICLE (p,π) TRANSITIONS ON LIGHT TARGETS

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(p,π) reactions necessarily involve large momentum transfer, typically greater than 500 MeV/c. An important part of the reaction operator has the effect on the target of creating a hole and inserting two nucleons, thus creating three- (or one-) quasiparticle states relative to the target. The amount of momentum transfer for each of the three nucleon states involved is about the same as in the inelastic scattering regime where high-spin states are selectively excited, so it is not strange that there is a tendency for high-spin states to be strong in (p,π) reactions. The most striking experimental evidence for the three-quasi-particle mechanism comes from the (p,π^-) reaction in particular from the analyzing powers and intensity ratios observed by Jacobs et al.,[1] in $^{12,13,14}C(p,\pi^-)$ ground-state transitions, especially from the strong population of $19/2^-$ and $15/2^-$ states by Vigdor et al.[2] in $^{48}Ca(p,\pi^-)$ and reactions on neighboring targets, and the correspondence of the latter with the model calculations of Brown, Scholten, and Toki.[3]

(p,π^+) reactions should also strongly populate two-particle, one-hole states of high spin through similar mechanisms. The largest elementary cross section for pion production is $pp \rightarrow pn$ (T=0), so the strongest (p,π^+) transitions should proceed through these channels in the nucleus with $\Delta T = 1/2$. Because the (p,π^+) reaction may be a way to excite unknown or poorly known high-spin three-quasiparticle states, we have studied (p,π^+) with targets of ^{16}O, ^{14}N, and ^{15}N.

The basic transition we hoped to identify is $(p_{3/2})^{-1}\ (d_{5/2})^2$, coupled to large angular momentum ($13/2^-$, $11/2^-$, $9/2^-$, etc.). These final states can be reached by M4 excitation from the ground state of ^{17}O, but cannot be reached by two-particle transfer from ^{15}N. It was also important to study the transitions $(p_{1/2})^{-1}(d_{5/2})^2$, which can be reached by E3 inelastic scattering and by two-particle transfer from ^{15}N.

The three reactions $^{16}O(p,\pi^+)$, $^{14}N(p,\pi^+)$, and $^{15}N(p,\pi^+)$ were studied with polarized 200 MeV protons, using the QQSP spectrometer at IUCF. The targets were in the form of V_2O_5, $V^{14}N$, $V^{15}N$, and V for subtraction. $^{12}C(p,\pi^+)$ was used for energy calibration.

Figure 1 shows the $^{16}O(p,\pi^+)^{17}O$ spectrum at 50°. Above the ground and 0.87 MeV one-quasiparticle states, there are states at 5.24 and 7.76 MeV. These are $9/2^-$ and $11/2^-$ states of the $(p_{1/2})^{-1}\ (d_{5/2})^2$

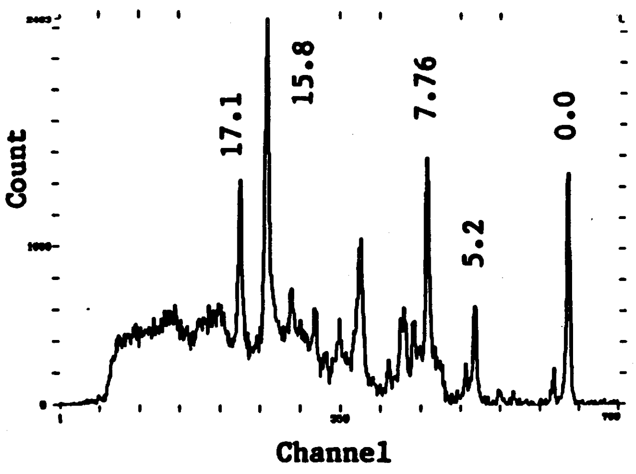

Figure 1. $^{16}O(\vec{p},\pi^+)$ spectrum at E_p=200 MeV and θ_{lab} = 50°. The excitation energies of some final states are indicated.

configuration. The same states are seen in $^{15}N(\alpha,d)$[4] and $^{15}N(^3He,p)$,[5] and the $11/2^-$ state in (e,e')[6] and (π,π').[7] The cross section of the $11/2^-$ state is relatively featureless except for an exponential decline of the cross section (Fig. 2-a) and an $A_y(\theta)$ reaches about −0.8 near 60°. At higher excitation there are strong states at 15.8 and 17.1 MeV. Their energies are determined to about 0.05 MeV, and they agree with values found in (π,π')[7] and (e,e')[8] for M4 transitions. As seen in Figs. 2b and 2c, their cross sections decrease by a factor of about 10 in going from 30° to 70° and are almost flat after that; their analyzing powers are consistent with being zero or slightly negative.

With ^{14}N as the target, we start with two quasiparticles and can reach in ^{15}N three-hole, two-particle states relative to ^{16}O. If the three holes are all in the $p_{1/2}$ orbital the maximum spin is 11/2 (for T = 1/2). $11/2^-$ and $9/2^-$ states are seen in (α,d) at 13.00 and 11.94 MeV.[4] If one of the holes is in $p_{3/2}$ the maximum spin is 15/2; these states are not known at present.

Figure 3 shows the spectrum of $^{14}N(p,\pi^+)^{15}N$ at 50°. Many states are populated, especially between 5 and 14 MeV. Most of these states are identified in other reactions, particuarly (α,d)[4] and (π,π').[9] At high excitation there is a new state at 21.5 MeV. The cross section and A_y of this state are similar to those of the 15.8 and 17.1 MeV states in ^{17}O.

When the target is ^{15}N, we can reach two-particle, two-hole states in ^{16}N. The strongest transitions ($pp\rightarrow pn(T=0)$) leading to $(p_{1/2})^{-2}$ will have a maximum spin of 5. The (α,d) work has identified a 5^+ state at 5.75 MeV. If one of the holes is in $p_{3/2}$, the maximum spin is 7. Little is known about such high-spin isovector states in the mass 16 spectrum.

In the $^{15}N(p,\pi^+)^{16}N$ spectrum (Fig. 4) the ground-state quartet is strongly populated, a 5^+ state is seen at 5.75 MeV, and the 4^- state known from charge-exchange work[10] is seen at 6.17 Mev. In addition there are strong new states at 14.15 and 16.0 MeV, whose cross sections also fall rapidly from 30° to 70°, with zero or slightly negative A_y.

It is tempting to associate the strong, high-excitation transitions (15.8 and 17.1 MeV in ^{17}O, 21.5 MeV in ^{15}N, 14.15 and 16.1 MeV in ^{16}N) with those

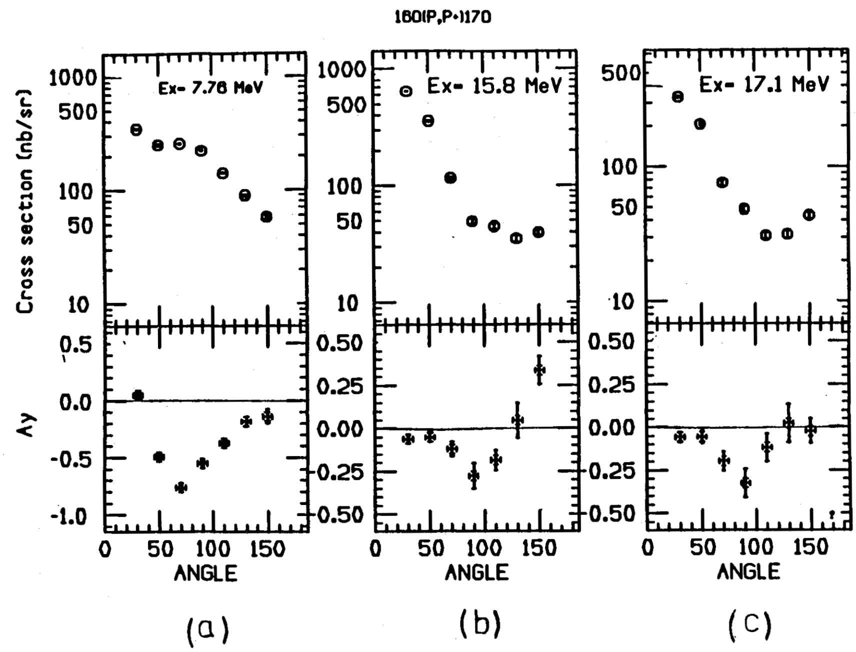

Figure 2. Preliminary $d\sigma/d\Omega$ and A_y angular distributions for the $^{16}O(p,\pi^+)$ transitions to ^{17}O states at: a) Ex = 7.76 MeV, b) E_x = 15.8 MeV and c) E_x = 17.1 MeV.

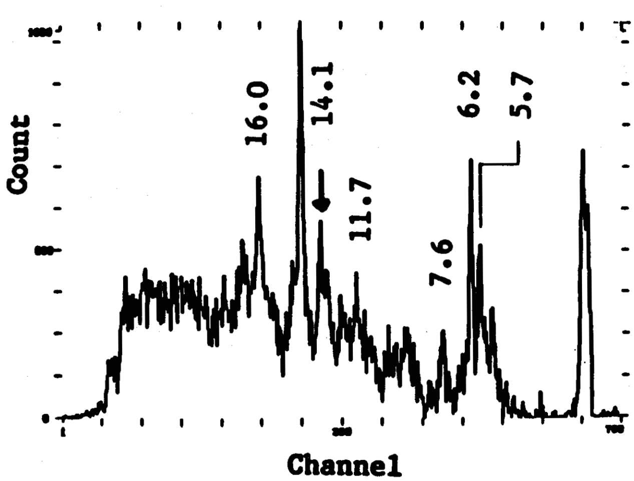

Figure 3. $^{14}N(\vec{p},\pi^+)$ spectrum at E_p = 200 MeV and θ_{lab} = 50°. Some final states are labeled by their excitation energies.

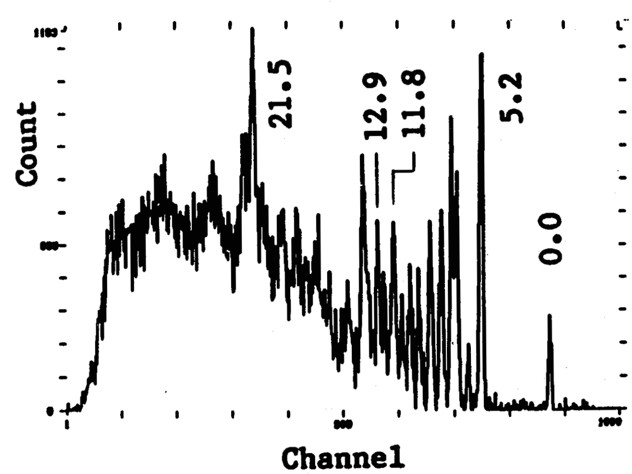

Figure 4. $^{15}N(\vec{p},\pi^+)$ spectrum at E_p = 200 MeV and θ_{lab} = 50°. Some ^{16}N states are labeled by their excitation energies. The peak marked by an arrow is the ^{17}O state (15.8 MeV).

seen recently (21.4 MeV in ^{13}C and 23.2 MeV in ^{14}C) by Korkmaz et al.[11] which have similar angular distributions of cross section and A_y. It is also tempting to associate them with the expected $(p_{3/2})^{-1}$ $(d_{5/2})^2$ transitions, since those in ^{17}O match the excitation of the M4 transitions observed in inelastic scattering. If the latter identification were to hold, however we would have to understand why the cross section distributions are so different for these states compared to the $11/2^-$ state in ^{17}O.

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$A(\vec{p},\pi^{\pm})$ CONTINUUM ANALYZING POWERS AND QUASI-FREE EXPECTATIONS

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We have seen considerable evidence accumulated in recent years that pion production reactions on nuclei $A(p,\pi)A+1$ are dominated by a two-nucleon mechanism (TNM), i.e., by $NN \rightarrow NN\pi$ processes ocurring within the nuclear medium.[1-7] While the arguments made in conjunction with these studies do depend on the explicit participation of two nucleons (one from the target nucleus), they do not require treating pion production as a quasifree $NN \rightarrow NN\pi$ process. Indeed, one might expect a priori quite different off-shell behavior for pion production in a free two-nucleon collision vs. one ocurring inside a nucleus.[8] We have recently studied $(\vec{p},\pi^{\pm})$ reactions on $^{12,13}C$ targets, with results bearing on two separate aspects of free $\vec{N}N \rightarrow NN\pi$ processes that are reasonably well established near threshold: the analyzing power behavior and the isospin dependence of the amplitudes. We focus on the striking results of the former in this contribution, which has been the subject of a recent publication.[9]

π^+ and π^- continuum analyzing powers at several values of $\langle E_x \rangle$, and for various targets are displayed in Fig 1. The negative going shape of $A_y(\Theta)$ for