INVESTIGATIONS OF CONCENTRATED (p,π^-) REACTION STRENGTH ON Ca ISOTOPES

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In the continuing investigation[1,2,3] of high-spin stretched or nearly-stretched 2 particle (protons) - 1 hole (neutron) states in $(p,\pi-)$ reactions we have completed measurements on $^{48}Ca(p,\pi^-)^{49}Ti$ at E_p = 166 and 205 MeV and on $^{42}Ca(p,\pi^-)^{43}Ti$ at E_p = 205 MeV. The most recent data taken at 166 MeV, along with a measurement at 190 MeV taken with the QQSP spectrometer at zero degrees,[4] have allowed us to remove a longstanding concern about the energy calibration of the ^{49}Ti spectra. In both of these measurements, the ground state (p,π^-) peak was observed with adequate statistics to fix the excitation scale, allowing us to assign energies of 4.4 ± 0.1 MeV and 4.0 ± 0.1 MeV to the two states most strongly excited. Tentative spin and parity assignments of $19/2^-$ and $15/2^-$ to the 4.4 and 4.0 MeV states, respectively, are supported by a number of independent measurements and calculations. Recent measurements on $^{51}V(d,\alpha)^{49}Ti$ carried out at IUCF[5] have resulted in the identification of high-spin states with $J_{transfer}$ = 7 at excitation energies consistent, within error, with the states seen in (p,π^-). $^{48}Ca(\alpha,3n\gamma)^{49}Ti$ studies[6] have assigned a spin and parity of $19/2^-$ to a state at E_x = 4.38 MeV in ^{49}Ti, in good agreement with our new energy calibration. In addition, shell model calculations of B.A. Brown et al.[7] have qualitatively reproduced our observed spectra (see Fig. 1); specifically, the location of the $19/2^-$, $15/2^-$ and $17/2^-$ states in the calculation agree, within error, with the peaks we have identified. Furthermore, the angular distributions measured for the 4.4 and 4.0 MeV transitions at E_p = 166 MeV (see Fig. 2) are very different from one another, in a manner qualitatively consistent with expectations based on simplified model calculations.[7]

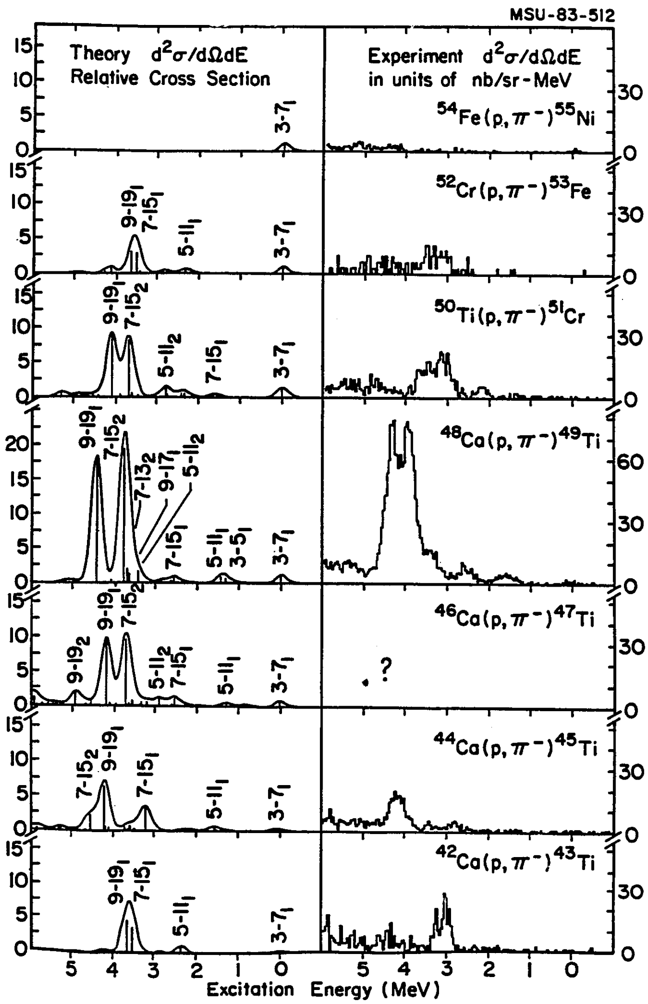
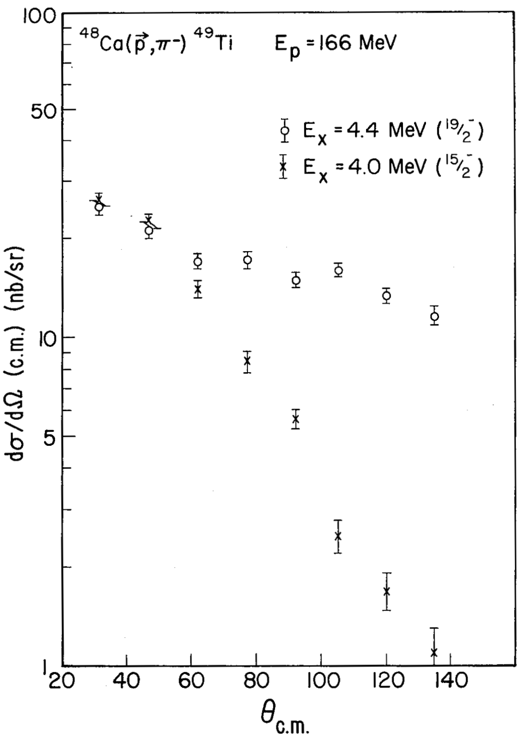
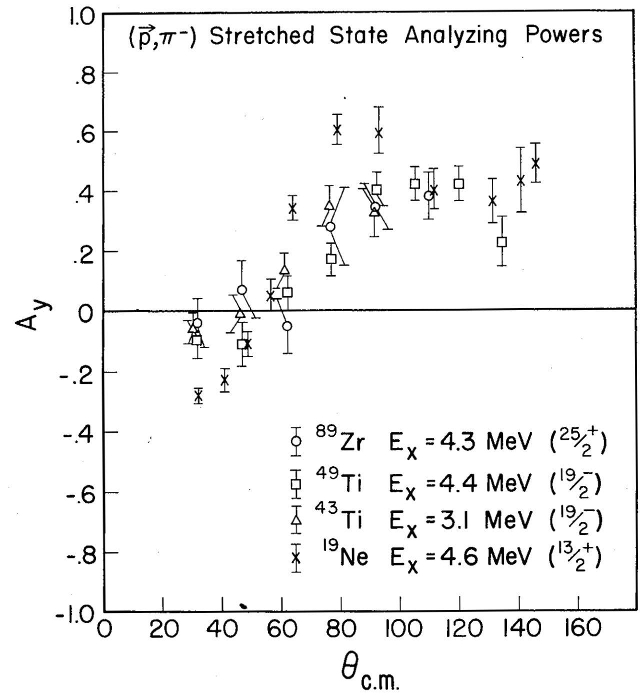


Figure 1. Comparison between calculated relative cross sections (Ref. 7) and experimental (p,π^-) cross sections for $f_{7/2}$- shell target nuclei at E_p = 206 MeV and Θ_{lab} = 30°. In the theoretical spectra, the individual states are indicated by lines labeled by $L\text{-}2J_\nu$, while the curve represents a gaussian average with Γ_{FWHM} = 0.3 MeV.

The most striking feature observed in the preliminary analysis of the data is a remarkable similarity in the analyzing power angular distributions



<u>Figure 2.</u> Cross section angular distributions for <u>19/2⁻ (E_x = 4.4 MeV)</u> and 15/2⁻ (E_x = 4.0 MeV) states in $^{48}Ca(p,\pi^-)^{49}Ti$ at E_p = 166 MeV.



<u>Figure 3.</u> Analyzing power angular distributions for the <u>2p-1h stretched</u> state configurations excited in the (p,π^-) reaction on target nuclei ^{88}Sr (Ref. 9, E_p = 175 MeV), ^{48}Ca (E_p = 166 MeV), ^{42}Ca (E_p = 205 MeV), and ^{18}O (Ref. 8, E_p = 201 MeV). (Shell model calculations indicate that the ^{43}Ti state may be a doublet with spins 19/2⁻ and 15/2⁻.)

of the stretched high-spin states of the two targets (Fig. 3). This feature is even more striking when one compares these angular distributions with those of stretched states populated in $^{18}O(p,\pi^-)^{19}Ne$[8] and $^{88}Sr(p,\pi^-)^{89}Zr$.[9] In all four cases one sees the same structure in the angular distribution -- A_y is negative forward of 60°, with a rapid rise to positive values at back angles. These similarities over a wide range of target mass and final state spin, when contrasted with the dissimilarity, in each case, of the distributions for the highest and next-highest spin states, suggests that the observed analyzing power distributions may constitute an experimental signature for the population of stretched states in the (p,π^-) reaction. As of yet, however, we cannot simply explain the observed analyzing power systematics.

A persistent feature of the continuum region of all (p,π^-) spectra from targets with $A \geqslant 30$ is a nearly linear rise in the π^- yield beginning at or near the location (or suspected location) of the stretched states. This linear rise led us to speculate that the low-lying 2p-1h high-spin states were acting as "doorways" into more complicated states in the continuum region reached via rescattering of the π^-. This speculation was reinforced by the observed similarity in cross section angular distribution shapes for E_p = 205 MeV between two excitation energy regions in the continuum of ^{49}Ti ($\langle E_x \rangle$ = 10.0 MeV and $\langle E_x \rangle$ = 5.5 MeV) and the concentrated high-spin strength region near E_x = 4 MeV (see upper right frame of Fig. 4).

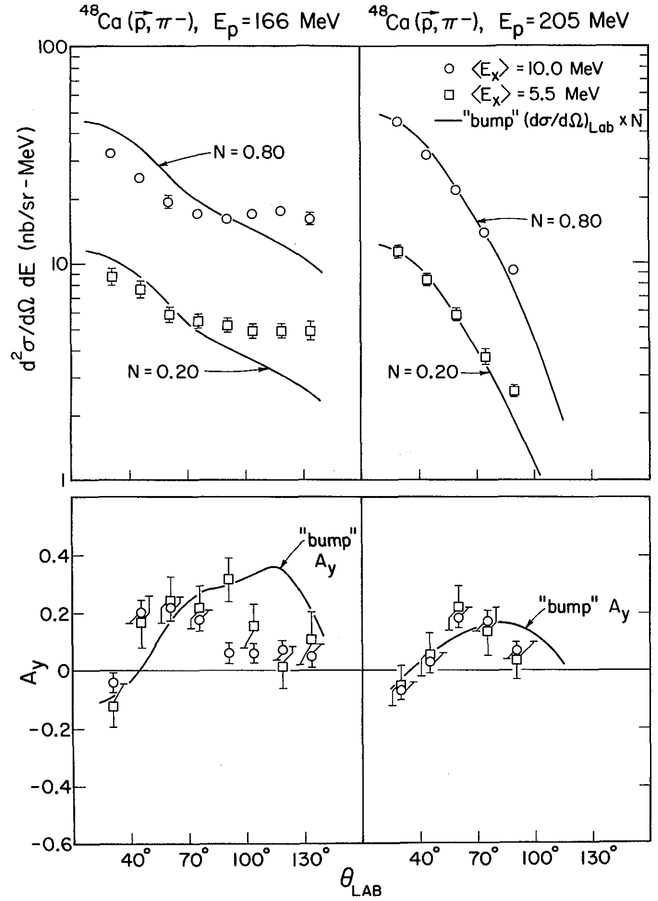


Figure 4. Cross section and analyzing power comparisons of two regions of the continuum ($\langle E_x \rangle$ = 10.0 MeV and $\langle E_x \rangle$ = 5.5 MeV) with that of the concentrated discrete strength in the $^{48}Ca(p,\pi^-)^{49}Ti$ spectrum at E_p = 166 and 205 MeV.

When one looks at the 166 MeV data one again sees the two excitation energy regions track each other, but the comparison with the strength concentration is less convincing. Similarly, the analyzing powers plotted in the lower half of Fig. 4 show a fair amount of consistency between different regions in the continuum, but the analyzing powers of the continuum do not simply track that of the strength concentration. Hence in light of the 166 MeV data, the idea that the strong discrete states act as doorway states for the continuum region appears less certain. A fuller understanding of the energy dependence of $d\sigma/d\Omega$ and A_y for both the discrete and continuous parts of the spectra over a broader energy range (up to the Δ resonance regime for the outgoing pions) for ^{48}Ca (as well as other target nuclei) may help shed light on this question.

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