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A SEARCH FOR Δ^- and Δ^{++}WAVE-FUNCTION COMPONENTS IN LIGHT NUCLEI USING THE (π^+,π^-p) AND $(n,2p)$ REACTIONS*

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We have studied the $(\pi^+,\pi^\pm p)$ reactions on ^{3}H, ^{4}He, ^{6}Li and ^{7}Li and the $(n,2p)$ reaction on ^{3}He and ^{4}He in quasi-free kinematics. A signature attributable to pre-existing Δ components of the ground state wave function is observed.

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Theoretical investigations first suggested nucleon resonances might play a role in nuclear structure in the 1960's. Meson models of nuclear binding predict virtual excitation of Δ's in nuclei at the several percent level. Detecting virtual Δ's at these levels has proven difficult because Δ production reactions usually dominate over knockout reactions.

Recently, a new method for measuring the Δ^- component of the nuclear wave function has been suggested and has given results which are in agreement with the theoretical predictions predictions for range of nuclei [1]. This method is based on pion double charge exchange (DCX) which cannot occur in a single step if the pion interacts with nucleons. However, since the isospin

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of the Δ is 3/2, it exists in four charge states and the double-charge-exchange reaction $\Delta^-(\pi^+,\pi^-)$p can occur in a single step. Due to isospin selection rules, the lightest nuclei in which single-Δ wave-function components can occur are ^{3}H and ^{3}He. Because of extensive calculations [2], mass-3 nuclei provide the ideal testing ground for comparing theory with experiment. The Δ fractions predicted in this body of work range from 1 to 3%. In the current work, we extended measurements of (π^+,π^-p) to the lightest stable nucleus for which this reaction is possible, ^{3}H. Measurements were also made on targets of ^{4}He, ^{6}Li, and ^{7}Li.

The experiment was performed using a 500-MeV beam from the P^3-East Channel at the Clinton P Anderson Meson Physics Facility. Pions from (π^+,π^+p), NCX and (π^+,π^-p), DCX reactions were observed at an angle of 50° in coincidence with protons at 52° using two magnetic spectrometers, in the kinematics of free πp scattering. The sum of the pion and proton energies was required to exceed 400 MeV. The experimental data show clear signature of quasi-two-particle kinematics. If these events are interpreted as due to $\Delta^-(\pi^+,\pi^-)$p reaction we extracted probabilities of preexisting

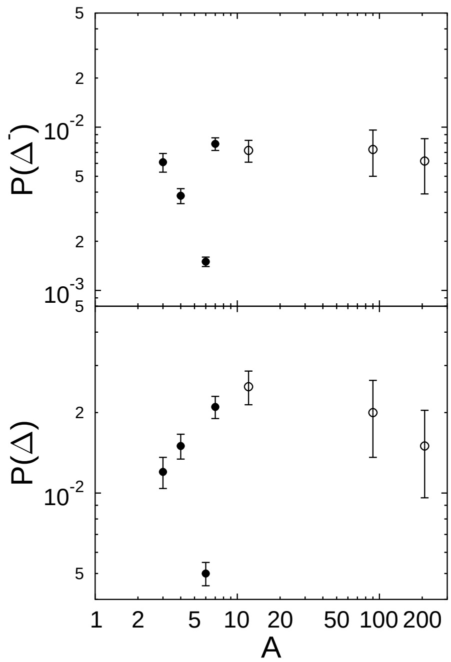

Fig. 1. A-dependence of extracted Δ^- fraction (top) and Δ fraction summed over charge states (bottom). Data from current experiment are shown as solid circles, previous data [1] are shown as open circles.

Δ component the same way as described in Ref. [1]. Figure 1 shows the A-dependence of the extracted Δ fraction as closed symbols along with previous data as open symbols [1]. A difference of a factor of four is observed in the cross sections and a factor of two in the extracted Δ^- fractions between ^{3}H and ^{4}He. A similar larger effect is observed in the comparison of ^{6}Li and ^{7}Li. The analysis yields two important conclusions. First, the magnitude of the Δ^- probability is larger in ^{3}H and appears to agree with theoretical expectations [2]. Second, the Δ^- probabilities in the light self-conjugate nuclei are significantly smaller than that in the T=1/2 nuclei. As

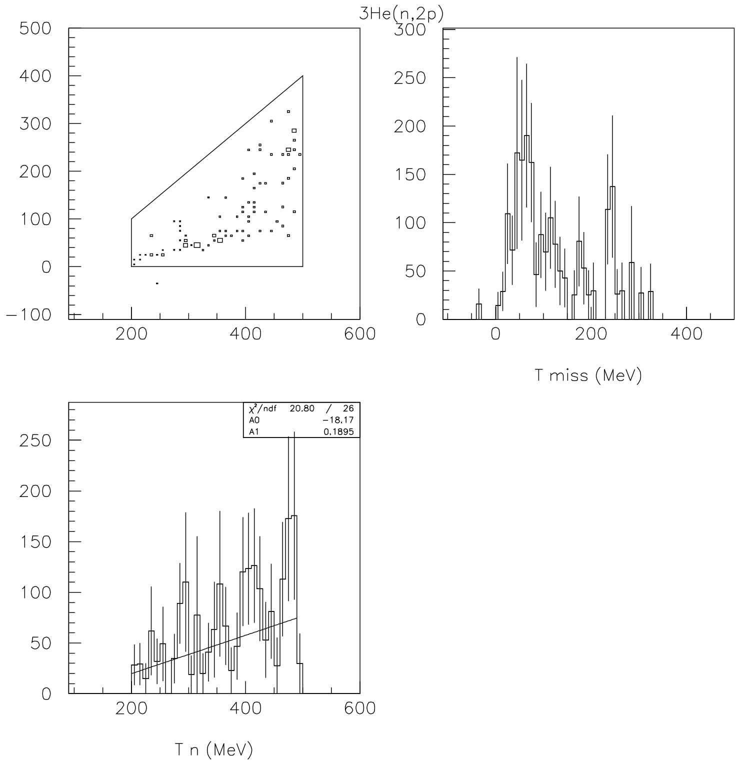

Fig. 2. Two-dimensional distribution of $T_{\rm miss} = T_n - Q - T_{2p}$ versus T_n (top left) and its projections (cross section) in arbitrary units. Contour shows experimental acceptance. Solid line is a straight line fit to guide the eye.

evidence for pre-existing Δ^- components has been obtained, it is natural to extend this study to other charge states of the Δ. Considering the $(n,2p)$ reaction, one sees that it also requires participation of at least two nucleons. However, as in the previous case of DCX, if a Δ^{++} component pre-exists in nuclei, the reaction $\Delta^{++}(n,2p)$ can occur in a single step. To test this idea, we have studied this process in ^{3}He and ^{4}He. Here we report the first preliminary results. The experiment was performed using the high-energy neutron beam at the WNR Facility at the Los Alamos Neutron Science Center. Protons from (n,p) and $(n,2p)$ reactions were detected by two $\Delta E-E$ scintillator telescopes placed at 40° and 50°, in the kinematics of free NN scattering. The incident neutron energy range was between 200 and 500 MeV. Figure 2 shows the measured two-dimensional distribution of missing energy ($T_{\rm miss}=T_n-Q-T_{2p}$) versus incident neutron energy, T_n. The top right plot is the missing energy spectrum; the bottom left plot is the energy dependence of the cross section. As in the DCX experiment the signature of a quasi-two-particle reaction is clearly seen in the missing energy spectrum. The observed difference in the cross sections for ^{3}He and ^{4}He is a factor of three, which is consistent with the expectation that the Δ^{++} probability in ^{3}He must be bigger. The $(n,2p)$ reaction cross section increases with incident neutron energy by more than a factor of three between 200 and 500 MeV, whereas for the (n,p) reaction it is almost constant. Indeed, available experimental data on free np-elastic scattering show that change in the cross section in this energy range does not exceed 20%. The cross section for the $pp\rightarrow n\Delta^{++}$ has been measured experimentally [3], allowing us to calculate the cross section for the inverse reaction, $n\Delta^{++}\rightarrow pp$, using detailed balance. The cross section varies from 2 mb at 200 MeV to 75 mb at 400 MeV. Our measured energy dependence of the $(n,2p)$ reaction cross section is not that strong. There are two possible explanations for this difference. First, the incident neutron interacts with a virtual Δ^{++}, which may shift the peak position. Second, the momentum distribution of the Δ^{++} will smear out a peak in the cross section.

The experimental results obtained can be considered as evidence for pre-existing Δ components in nuclei.

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