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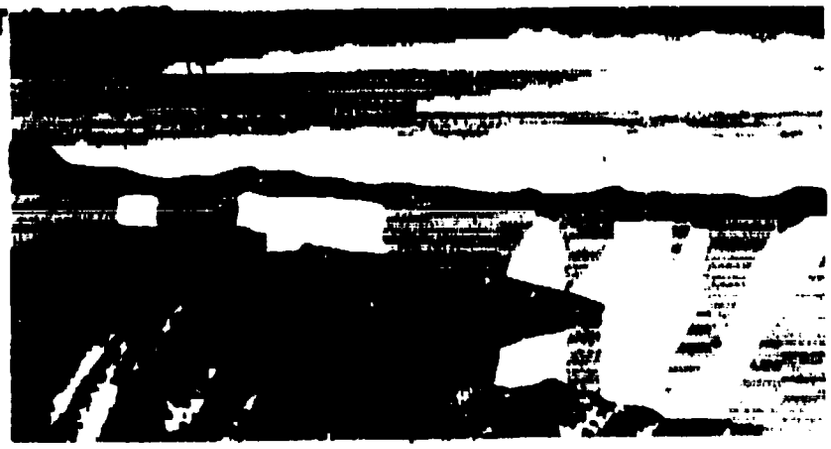

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A SEARCH FOR THE Δ^- WAVE-FUNCTION COMPONENT IN LIGHT NUCLEI

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We have studied the (π^+, π^+p) reactions on ^{3}H, ^{4}He, ^{6}Li, and ^{7}Li at incident energy 500 MeV in quasi-free kinematics. A signature attributable to pre-existing Δ components of the ground state wave function is observed.

Meson models of nuclear binding predict both excess pions and excited nucleons in nuclear matter.[1] Results from a new method of measuring the Δ component of the nuclear wave function using the pion double charge exchange (DCX) reaction (π^+, π^-) are reported in this paper.

If the nucleus contains only nucleons, two like-charge nucleons must participate in the DCX process. If the nuclear wave function contains a Δ^-, the (π^+, π^-) process can occur in a single step. Recent measurements on a range of nuclei have yielded evidence for this effect.[2] In the current work we have extended these studies to ^{3}H, ^{4}He, ^{6}Li, and ^{7}Li.

The experiment was performed using a 500 MeV beam 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.

An estimate of the probability for pre-existing Δ's can be obtained from the data by integrating the cross sections and forming the ratio $R = \sigma_{DCX}/\sigma_{NCX}$

$$P_\Delta = R\left(\frac{ZN_\Delta}{AN_\Delta^-}\right)\left(\frac{\sigma(\pi^+ + p \to \pi^+ + p)}{\sigma(\pi^+ + \Delta^- \to \pi^- + p)}\right)\left(\frac{k_\Delta}{k_F}\right)^3 . \qquad (1)$$

Table 1: Measured cross section ratios and extracted values of P_Δ.

Target	$\sigma_{DCX}/\sigma_{NCX}$ ($\times 10^3$)	P_{Δ^-} (%)	P_Δ (%)
^{3}H	8.9(6)	1.72(12)	3.44(24)
^{4}He	0.90(18)	0.26(5)	1.04(20)
^{6}Li	0.67(13)	0.20(4)	0.73(15)
^{7}Li	5.4(5)	1.58(15)	4.22(40)

where P_Δ is the sum of the probabilities for all Δ charge states, N_{Δ^-}/N_Δ is the fraction of Δ^-'s, Z and A are the proton and nucleon numbers, and k_Δ and k_F characterize the momentum spreads of the Δ's and nucleons. We have used measured branching ratios[3] for $N^*(1520) \to \pi + N$ and $N^*(1520) \to \pi + \Delta(1232)$ to estimate the cross-section ratio, and have taken $k_F = 200$ MeV/c and $k_\Delta = 400$ MeV/c, the peak of the momentum distribution predicted for the calculated pion excess.[1] The ratios of Δ charge states have been obtained by generalizing arguments given in[4] to give:

$$\frac{N_{\Delta^-}}{N_\Delta} = \frac{3}{4}\left(1 + \frac{Z}{2(N-1)} + \frac{Z(Z-1)}{N(N-1)}\right)^{-1}, \qquad (2)$$

where N is the neutron number of the nucleus. The measured cross section ratios and resulting Δ probabilities are given in Table 1

The Δ^- probability in ^{3}H is found to agree roughly with theoretical expectations.[5] Moreover, the Δ^- probabilities in the light self-conjugate nuclei are approximately an order of magnitude smaller than those in the T=1/2 nuclei. This is presumably because only core-excited two-particle configurations or $\Delta\Delta$ excitations can contribute to the Δ probabilities for neutron pairs coupled to J=0 within the s-shell.

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