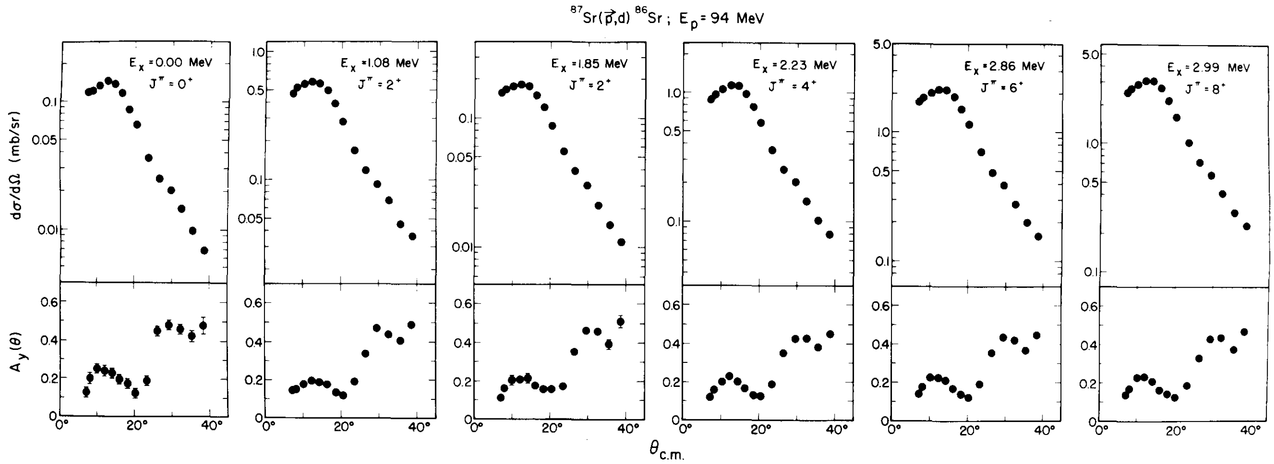


Figure 1. Differential cross section and analyzing power angular distributions for $\ell$=4 transitions in the $^{87}$Sr(p,d) reaction.

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## PROTON GROUND STATE CORRELATIONS IN THE EVEN CALCIUM ISOTOPES

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Using the strong selectivity of the (d,α) reaction at 80-MeV bombarding energy for picking up a proton-neutron pair in the stretched $(1f_{7/2})^2{}_{J=7,T=0}$ configuration, we started a systematic study on the even calcium isotopes in order to search for proton ground state correlations in the target nuclei. The $(1f_{7/2})^2{}_{7,0}$ transitions are characterized, and can be easily identified, by pure L=6 angular distributions of the differential cross section[1] and distinct J=7 patterns of the vector analyzing powers.[2]

Measurements were performed on $^{40}$Ca, $^{44}$Ca, $^{48}$Ca, and $^{50}$Ti using a 79.4-MeV vector polarized deuteron beam. Samples of typical L=6 angular distributions of the differential cross section are shown in the left panel of Fig. 1; the corresponding vector analyzing powers are presented in the right panel of Fig. 1. Unambiguous $(1f_{7/2})^2{}_{7,0}$ transitions were observed to the residual levels at 1.10 MeV in $^{48}$Sc (this state has the well known spin and parity $7^+$), at 4.54 and 5.95 MeV in $^{46}$K, at 1.91 MeV in $^{42}$K, and at 5.28 MeV in $^{38}$K. It should be noted that these transitions on the Ca target nuclei are almost as strong as that on $^{50}$Ti, where proton occupancy of the $1f_{7/2}$ orbital is a dominant piece of the ground-state wave function.

Microscopic DWBA calculations were performed in order to extract the proton occupation numbers for the

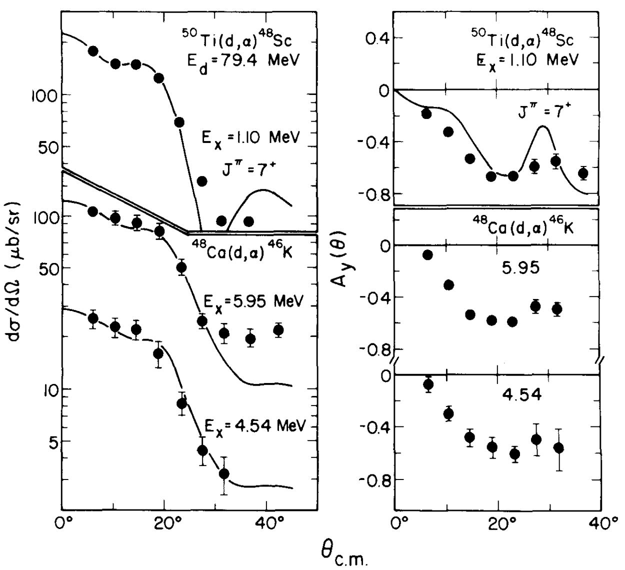


Figure 1. Differential cross section and vector analyzing power angular distributions for L=6 transitions in the $^{48}Ca(d,\alpha)$ and $^{50}Ti(d,\alpha)$ reactions.

$1f_{7/2}$ orbital in the ground states of $^{40}Ca$, $^{44}Ca$ and $^{48}Ca$ relative to $^{50}Ti$. If we followed the standard prescription for the two-nucleon transfer formfactor of using one-half of the actual separation energy of the proton-neutron pair in the spin triplet state as binding energy for each of the transferred nucleons, we obtain 1.55 ± 0.40, 1.65 ± 0.40 and 1.85 ± 0.45 for the $1f_{7/2}$ orbital occupation numbers in the $^{40}Ca$, $^{44}Ca$ and $^{48}Ca$ ground states, respectively. These occupation numbers are exceedingly large.

From the shell-model and single-nucleon transfer point of view, several comments can be made. First, the proton separation energies of the Ca isotopes as taken from the atomic mass tables reflect the separation energies from the sd orbitals and not from the $1f_{7/2}$ orbital. In the shell model picture, the $1f_{7/2}$ orbital in the Ca isotopes lies about 5 to 7 MeV above the sd orbitals, and thus the $1f_{7/2}$ proton binding energy should be smaller by this amount. Secondly, although the actual separation energy gives the correct asymptotic tail outside the nucleus, it does not assure that the wave function is correct elsewhere. The latter deficiency can be overcome by using measured root-mean-square radii of the valence nucleon radial wave functions[3,4] to constrain the potential radius.

With the above described effective binding energies of a $1f_{7/2}$ proton in the Ca isotopes, we obtain proton occupation numbers of 1.20 ± 0.35, 1.50 ± 0.40, and 0.95 ± 0.25. Finally, the constraint of using rms radii yields proton occupation numbers of 0.75 ± 0.20, 1.30 ± 0.35, and 0.65 ± 0.20 for the ground state wave functions of $^{40}Ca$, $^{44}Ca$, and $^{48}Ca$, respectively. These numbers agree quite well with previously obtained values,[5] except for $^{48}Ca$, where much larger proton ground state correlations are inferred from the present work.

In the near future the study of proton ground state correlations in the calcium region will be continued by measuring the $(d,\alpha)$ reaction on $^{46}Ti$, $^{45}Sc$ and $^{42}Ca$.

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