TEST OF THE DWBA DESCRIPTION OF TRANSFER REACTIONS AT INTERMEDIATE ENERGIES BY MEASURING A COMPLETE SET OF SINGLE NUCLEON TRANSFER AND ELASTIC SCATTERING DATA

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It is well known that the standard DWBA description of transfer reactions at intermediate energies fails in many cases to reproduce experimental data, especially analyzing power angular distributions.[1] On many occasions, it was found that better agreement with the experimental data could be achieved by reducing contributions from the nuclear interior when calculating the DWBA transition amplitude.[2] Besides the question of possible contributions from multistep processes not included in standard DWBA calculations, there are several possible sources of uncertainties in the DWBA analysis, two of which are: (i) the distorted waves in the entrance and exit channels, which are calculated from an optical potential that fits elastic scattering data, and (ii) the radial wave function of the bound state to (from) which the nucleon is being transferred. The latter uncertainty can be reduced considerably by using valence nucleon radial wave functions obtained from magnetic electron scattering.[3]

The present experiment is designed to measure a complete set of single-nucleon transfer and elastic scattering data in order to test the DWBA description at intermediate energies. As an initial study the $^{206}Pb(\vec{d},^{3}He)^{205}Tl$ and $^{87}Sr(\vec{p},d)^{86}Sr$ pickup reactions were chosen, since radial wave functions of the valence nucleons, $\pi(3s_{1/2})$ and $\nu(1g_{9/2})$, respectively, are accurately known. In addition, in each case, both target and final nuclei are stable, allowing a precise determination of the relevant distorted waves from elastic scattering analyses.

Angular distributions of the differential cross section and vector analyzing power have been obtained for the $^{206}Pb(\vec{d},^{3}He)^{205}Tl$ reaction and for elastic deuteron scattering on ^{206}Pb at 79.4 MeV bombarding energy. Elastic scattering of ^{3}He on ^{205}Tl was measured at 78.4 MeV incident energy. Moreover, differential cross sections and analyzing powers were obtained for the $^{87}Sr(p,d)$ and $^{87}Sr(p,p)$ reactions with 94.2-MeV polarized protons. The corresponding deuteron elastic scattering on ^{86}Sr at about 88 MeV bombarding energy will be measured in the near future.

The data are presently being analyzed. As an example, Fig. 1 shows the differential cross section and analyzing power angular distributions of $\ell=4$ transitions in the $^{87}Sr(\vec{p},d)^{86}Sr$ reaction. The first optical model fits using standard Woods-Saxon type potentials reproduce the elastic scattering data quite well for angles up to 60°. However, for angles above 60°, the calculations cannot account for the features of the elastic experimental data. These potentials reproduce the transfer differential cross sections fairly well, but fail to describe the corresponding analyzing-power angular distributions. The next step in this analysis will be the use of non-standard potentials to fit elastic scattering and test their ability to describe the transfer data.

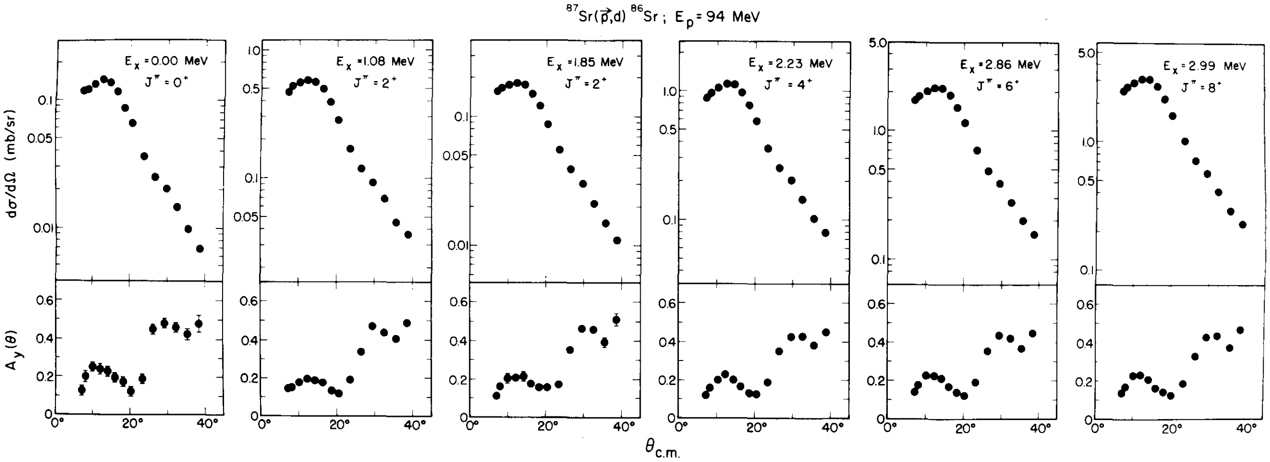

Figure 1. Differential cross section and analyzing power angular distributions for ℓ=4 transitions in the ^{87}Sr(p,d) reaction.

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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