the t-matrix. For the 5^- state, on the other hand, the calculated result for A_y is predominantly sensitive to central-spin-orbit interference, and the change of sign of A_y near 40° is rather well correlated with the change of sign in the central part of the t-matrix at the corresponding momentum transfer, as given by the Love interaction.

The differential cross sections and analyzing powers for the lower-lying states of ^{28}Si and ^{24}Mg have also been measured. In ^{24}Mg, for example, the excitation of states in the K=0 and K=2 bands can be compared to calculations using the Chalk River projected-Hartree-Fock wave functions. The remarkable agreement between theory and experiment for inelastic electron scattering[3] allows a detailed study of the proton scattering mechanism. The totally anomalous shape of the electromagnetic form factor for the 4_1^+(K=0) state in ^{24}Mg is well reproduced in the differential cross section for (p,p').

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SPIN-ORBIT EFFECTS IN THE EXCITATION OF PROTON AND NEUTRON STATES IN THE (p,p') REACTION AT 160 MeV, 120 MeV, AND 95 MeV

Alan Scott, F. Todd Baker, M.A. Grimm, J.H. Johnson, V. Penumetcha, R.C. Styles, J.A. Mowrey, and W.G. Love
University of Georgia, Athens, Georgia 30602

W.P. Jones and J.D. Wiggins
Indiana University Cyclotron Facility, Bloomington, Indiana 47405

Large differences in the shapes of measured differential cross sections were found earlier[1] for the excitations of the 4_1^+ proton state in ^{90}Zr and the 4_1^+ neutron state in ^{92}Zr. To obtain a good fit to the data for this proton state in ^{90}Zr with purely collective calculations, an enhanced spin-orbit contribution (β_4^{so}/β_4=1.25) was required, but no satisfactory fits were found for this neutron state in ^{92}Zr. Collective fits to the data for the 2_1^+, 4_1^+, 6_1^+, 8_1^+ proton states in ^{90}Zr showed[2] the increasing dominance of the spin-orbit contribution as the multipolarity increased. Recent calculations show the cross sections for the 2_1^+, 4_1^+, 6_1^+, and 8_1^+ states in ^{90}Zr to be underpredicted in the DWIA by factors of 30, 10, 3, and 2 respectively when only the $(g_{9/2})^2$ valence terms are included for the central, spin-orbit and tensor amplitudes,[3] suggesting the need for core polarization amplitudes similar in magnitude to those required at lower energies.[4,5] These DWIA calculations showed the relative importance of the spin-orbit part of the t-matrix increased in this sequence as the multipolarity increased.[3] The dominance of the spin-orbit contributions for the 8_1^+ state in ^{90}Zr is shown in the DWIA and collective calculations of Figures 1(a) and 1(b) respectively.

Large spin-orbit effects at this energy (E_p= 160 MeV) clearly suggested the need for (p,p') asymmetry measurements. Analyzing power data have been obtained at 14 angles from 16° to 44° for the 2_1^+, 4_1^+, 5_1^-, 3_1^-, and 2_2^+ states in ^{90}Zr and for the 2_1^+, 4_1^+, 3_1^-, 2_2^+, 2_3^+, and 5_1^- states in ^{92}Zr, and at 8 angles from 26°

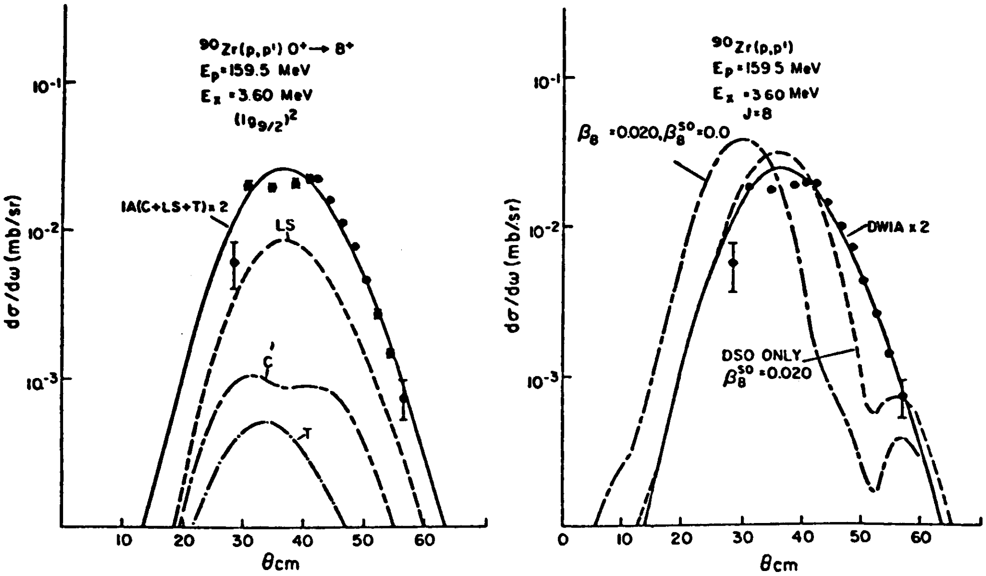

Figure 1. (a) DWIA calculation multiplied by factor of two. (b) Collective calculations with DSO only; DWIA calculation shown for comparison.

to 44° for the 6_1^+ and 8_1^+ states in ^{90}Zr. Large differences are found between the analyzing power data for the 4_1^+ proton state in ^{90}Zr and the 4_1^+ neutron state in ^{92}Zr, differences which increase as the angle of scattering increases (see Fig. 2). The ^{90}Zr data are plotted with crosses, the ^{92}Zr data with dots. Figure 2 also shows that the collective calculation (with enhanced spin-orbit contribution) which gave the best fit to the measured cross section for this ^{90}Zr state is a poor fit to the measured analyzing power data. DWIA calculations (with the t-matrix of Refs. 3 and 6, and collective core polarization amplitudes) which give good fits to the measured cross sections for these 4_1^+ states in ^{90}Zr and ^{92}Zr fail quite badly to describe the shape of the measured analyzing power data for each of these cases. Collective model calculations give

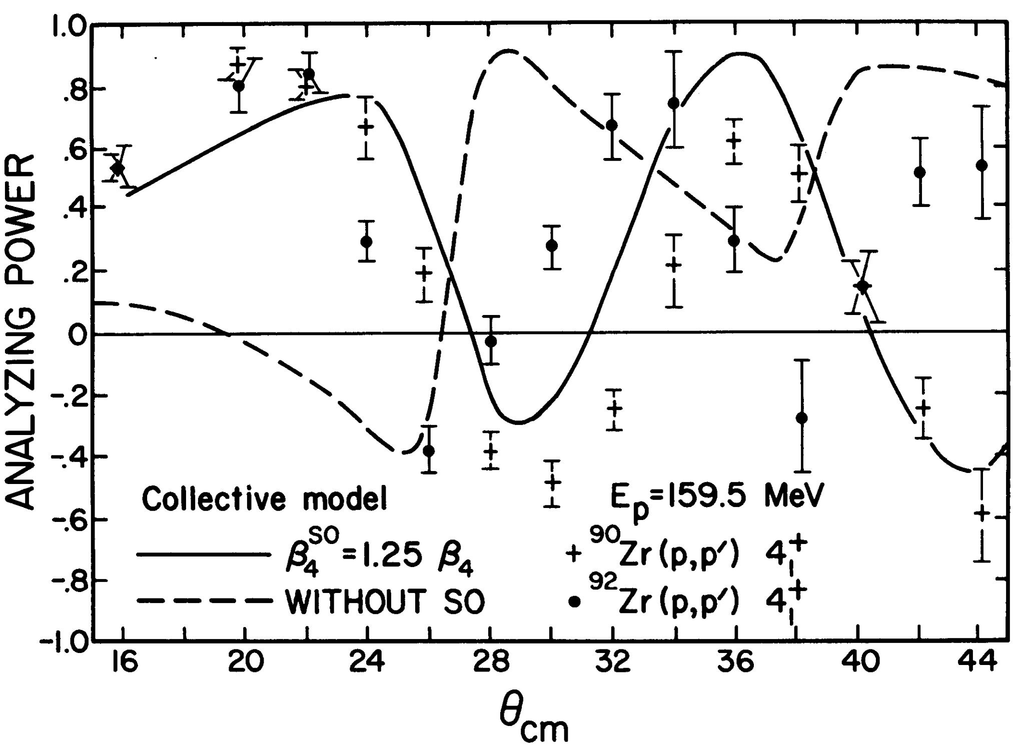

Figure 2. Crosses are data for the ^{90}Zr 4_1^+ state and dots are data for the ^{92}Zr 4_1^+ state. Collective calculations do not fit either transition well.

much poorer fits to the analyzing power data for this 4_1^+ state in ^{92}Zr than for the 4_1^+ proton state in ^{90}Zr.

There are smaller but still quite large differences between the shapes of the asymmetries measured for the 2_1^+ proton state in ^{90}Zr and the 2_1^+ neutron state in ^{92}Zr, but there are only slight differences in the analyzing powers measured for the collective 3^- states in ^{90}Zr and ^{92}Zr. It appears, therefore, that the differences in the data for these 2_1^+ and 4_1^+ proton and neutron states in ^{90}Zr and ^{92}Zr may well be due to differences in the relative importance of the valence and core polarization amplitudes caused by the different wave functions and by differences in the p-p and p-n parts of the nucleon-nucleon force in these proton and neutron transitions.

Figure 3 shows the analyzing power measured for the 8_1^+ proton state in ^{90}Zr. Collective model calculations are shown for the ratio β_8^{so}/β_8 equal to zero, 1.5 and 8.0. The data are clearly best fitted by the calculation most dominated by the spin-orbit contribution, the situation already found for the collective and DWIA fits to the cross section measured for this transition.

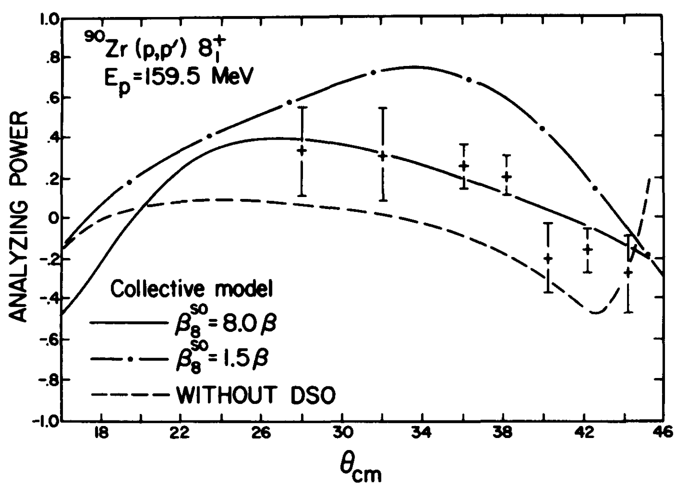

Figure 3. Collective calculations for the ^{90}Zr $0^+ \to 8_1^+$ transition with β_8^{so}=8.0 β_8.

Another beam run is scheduled for March 1980, to obtain data at angles beyond where the preliminary data show the largest differences in the observed analyzing powers for the 2_1^+ and 4_1^+ states in these two nuclei, and at angles between 10° and 44° where there are maxima and minima in the analyzing powers since the magnitudes of theoretical calculations at these points appear sensitive to the size of the spin-orbit contributions.

In the case of the ^{89}Y(p,p') reaction at 160 MeV, differential cross sections have been obtained for all low-lying states up to about 3 MeV of excitation, over the angular range from 10° to 56°.

Of special interest is the excitation of the single-proton $9/2^+$ state at 0.908 MeV, because interpretations[5] of data from an earlier experiment at E_p= 61 MeV required the inclusion of a significant L=3 spin-flip amplitude and an M4 core polarization amplitude, in addition to the L=5 amplitudes. The inclusion of this L=3 amplitude caused the overall theoretical cross section to match the shape of the data for this transition in ^{89}Y. This shape is quite different to the shape of the cross section for the excitation of the 5^- state in ^{90}Zr at the same E_p= 61 MeV because no L=3 amplitude is allowed to contribute to this transition in ^{90}Zr. Figure 4 shows that the measured cross section for this state in ^{89}Y (in the present experiment at E_p= 160 MeV) is quite different in shape from that for the 5^- state in ^{90}Zr at the same projectile energy. The higher contributions at forward angles of this ^{89}Y cross section, when compared with the data and collective L=5 calculations (with β_5^{so}/β_5= 2.9) for this 5^- state in ^{90}Zr, suggest that microscopic model calculations will need a significant forward-peaked L=3 cross section added to the L=5 cross section to fit this ^{89}Y data. Comparison of microscopic model fits to these data for E_p= 160 MeV with fits to the 61 MeV data[5] should thus provide valuable information on the energy dependence of the contributing amplitudes, especially for the spin-dependent amplitudes.

The shapes of the measured cross sections for the other two single-proton states at 1.51 MeV and 1.74 MeV are quite different at E_p= 160 MeV. Since there are valence amplitudes which can contribute to the transition to the 1.51 MeV state which cannot for the 1.74 MeV state,[7] and the spin-orbit force is more dominant at E_p= 160 MeV, it is expected that different relative magnitudes of the contributing amplitudes at this energy and at the lower E_p= 61 MeV will assist in the determination of the magnitudes of these amplitudes, especially the spin-orbit amplitude.

Data have been obtained at E_p= 120 MeV in the ^{90}Zr(p,p') reaction for the 2_1^+, 4_1^+, 6_1^+, 8_1^+, 5_1^-, 3_1^-, and 2_2^+ states in ^{90}Zr, over the angular range from 10° to 70°. Peak stripping and data analysis are now almost completed. Comparisons of microscopic model analyses for these data at E_p= 120 MeV with analyses for our previous experiments[1,2,5] at 61 MeV and 160 MeV are expected to provide information on the energy dependence of valence and core polarization amplitudes, especially the spin-orbit amplitudes.

Differential cross sections have been measured in the ^{207}Pb(p,p') reaction at 95 MeV for the four low-lying neutron-hole states which involve angular momentum transfers of 2, 2, 4, and 7, and for the doublet at 2.64 MeV. Microscopic model DWBA calculations have been made for these transitions to the neutron-hole states using the M3Y force,[8] and DWIA calculations have been made with the t-matrix from nucleon-nucleon scattering at 100 MeV. An article is in preparation which compares these results with similar data and analyses of experiments at 61 MeV and 135 MeV.

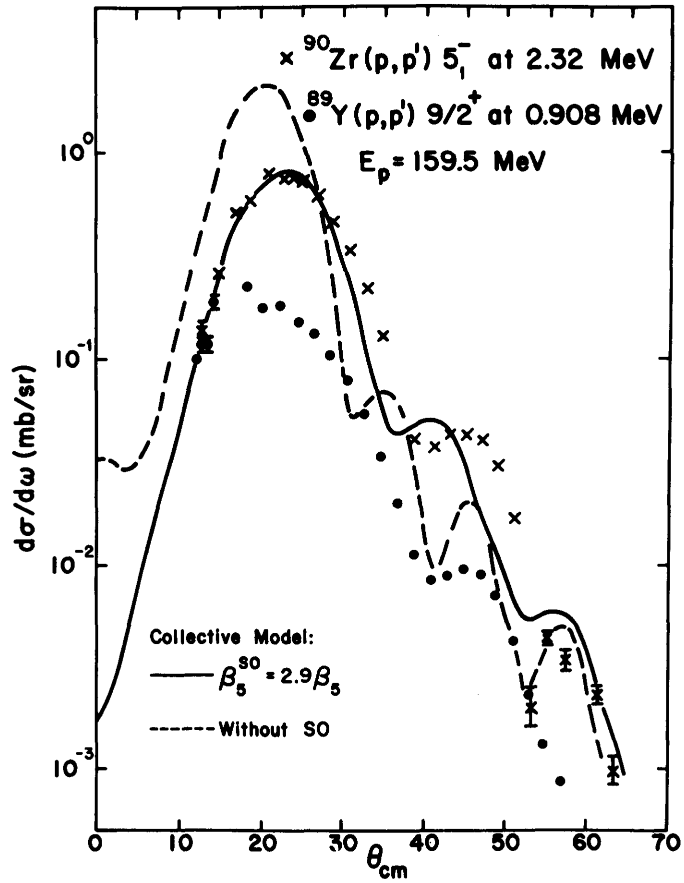

Figure 4. Comparison of data for the 5^- state in ^{90}Zr and the $9/2^+$ state in ^{89}Y. Also shown are DWBA L=J=5 calculations.

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