A TEST OF THE COPLANAR AND FAR-SIDE FEATURES OF INTERMEDIATE ENERGY (d,p) REACTIONS

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During the analysis of our data from the ^{116}Sn(d,p)^{117}Sn reaction[1,2] at E_d = 79 MeV, we observed data trends which conventional DWBA could not reproduce. In an attempt to improve agreement with experiment several features were added to the DWBA, viz. an adiabatic prescription for the deuteron scattering wavefunction[3] (hereafter referred to as ADWA calculations), a finite range treatment of both the deuteron S- and D- states,[4] matched entrance and exit channel geometries, and non-locality corrections.[5] Calculations incorporating all of these changes were made using the program TWOFNR,[6] and it was found that these extra features did produce significant improvements in the agreement between Distorted Wave calculations and the ^{116}Sn(d,p)^{117}Sn data. However agreement of the ADWA calculations with data for the $j = \ell-1/2$, $7/2^+$, 0.712 MeV transition, particularly the A_{yy} tensor analyzing power, remained very poor.

In an attempt to understand the disagreement between experimental data and Distorted Wave calculations for this well-matched transition, we attempted to identify the dominant characteristics of the ADWA calculation and find ways to confirm them experimentally. When the angular momentum transfer is large, the characteristics are:

1. The cross section is dominated by contributions from the far side of the nucleus through the action of the attractive parts of the real central and real spin-orbit potentials.
2. The neutron is stripped into an orbit that is coplanar with the asymptotic reaction plane. Stated another way, the recoil nuclear state is populated by only one projection of the neutron angular momentum, $m_n = \ell_n$, when the quantization axis is perpendicular to the reaction plane.
3. There is very little spin flip in either the entrance or exit channel.

When all of these characteristics are strictly true, it can be shown that only two reaction amplitudes survive for $j = \ell-1/2$ neutron coupling. Thus all spin observables are redundant and various linear combinations of the analyzing powers will vanish, thereby generating various relationships among these spin observables which can be tested against experiment. One such relationship, $A_y = -(2+A_{yy})/3$, was tested against our ^{116}Sn(d,p)^{117}Sn ($7/2^+$,0.712) data in Fig. 1. The high degree to which the model follows the above characteristics is supported by the observation that the calculated value of $A_y + (2+A_{yy})/3$ is less than 0.1 for a full Distorted Wave calculation using only the deuteron S-state. However the data suggests a substantial breaking of these rules.

We first considered the possibility of significant spin-flip in the deuteron channel. Spin-flip

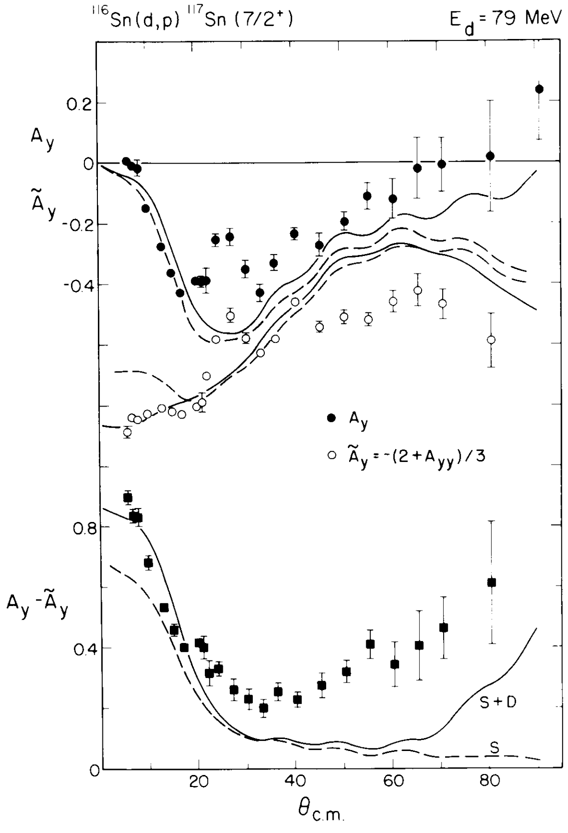


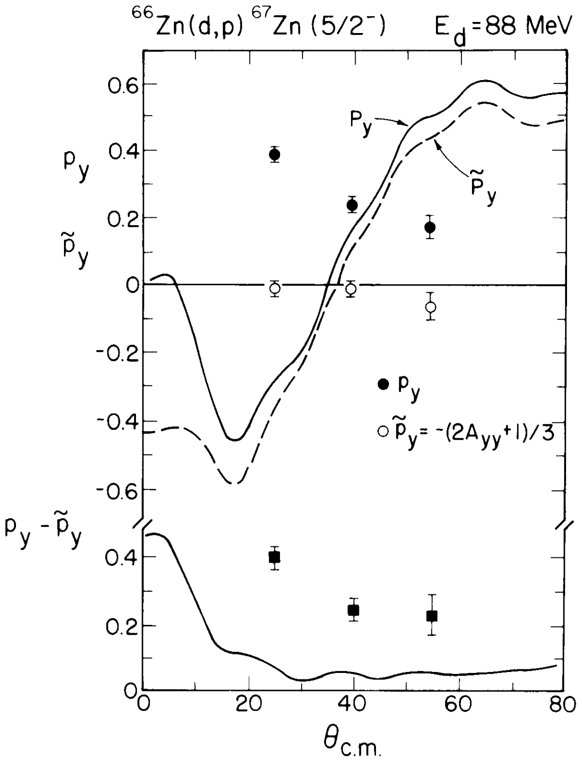
Figure 1. Experimental and calculated angular distributions of A_y and its counterpart $\tilde{A}_y \equiv -(A_{yy} + 2)/3$ for the $7/2^+$ transition in the ^{116}Sn(d,p)^{117}Sn reaction. The bottom portion shows the difference, A_y-Ay. The solid (dashed) curves include (neglect) the deuteron D-state.

contributions to $A_y+(A_{yy}+2)/3$ can originate in stripping from the deuteron D-state, tensor forces between the deuteron and the nucleus, and coupling to breakup states with relative n-p angular momentum greater than zero. Generating a larger spin-flip amplitude by including the deuteron D-state in our calculations, as shown in Fig. 1, helps, but it still does not reproduce the data. Additional calculations suggest that the tensor force effects are insignificant for this case.[8]

There is clearly a problem with the Distorted Wave calculations, and it is important to resolve whether these come from other contributions (such as breakup) to the spin-flip amplitude or a deviation from one of the other two characteristics. It can be shown that the linear combination $p_y + (2A_{yy}+1)/3$ is sensitive to only amplitudes where $m_n \neq \ell_n$, thus constituting a different test of the calculation.

A comparison of the outgoing polarization and the A_{yy} tensor analyzing power can best be performed for a case where the $j = \ell-1/2$ transition connects the ground states of two stable and reasonably abundant isotopes. Then the polarization may be measured by observing the analyzing power in the time reversed reaction. One such transition is the $5/2^-$ ground state reaction in ^{66}Zn(d,p)^{67}Zn. Thus selected measurements of the A_{yy} tensor analyzing power and the outgoing proton polarization in the ^{66}Zn(d,p)^{67}Zn($5/2^-$,g.s.) reaction at E_d = 88 MeV were made in the spring of 1985. The experimental method was identical to that outlined in Ref. 9. A new calibration of the beam line 2 polarimeter for deuteron energies above 80 MeV is described in Ref. 10. The results of these measurements along with calculations including the deuteron D-state are shown in Fig. 2. The calculation seriously underestimates the measured values of $p_y + (2A_y+1)/3$, indicating that it obeys the characteristics given previously while the data does not.

A forward angle oscillation pattern (See Fig. 1) present in the angular distribution measurements of the ^{116}Sn(d,p)^{117}Sn reaction was usually absent in the calculations. The oscillation period suggests that there are comparable contributions from both the near and far sides of the nucleus, which would invalidate both of the first two characteristics and provide a basis for understanding the violations depicted in Figs. 1 and 2. The momentum matching that makes cross-



<u>Figure 2</u>. Experimental and calculated angular distributions for the outgoing proton polarization p_y and its counterpart $\tilde{p}_y \equiv -(2A_{yy} + 1)/3$ for the $5/2^-$ ground state transition in the ^{66}Zn(d,p)^{67}Zn reaction. The bottom portion shows the difference, $p_y - p_y$. The curves are full Distorted Wave calculations.

sections for these states large also overwhelms the much smaller near side contribution. Such a near side contribution can be generated only if the physics described in the Distorted Wave model of transfer reactions is substantially changed. The nature of such a change is currently unknown.

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