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1.57 Empirical Investigation of Far-side Dominance in $j = \ell - \frac{1}{2}$ Transfer (d,p) reactions at Intermediate Energy

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Reaction calculations for well orbital angular momentum (ℓ) matched (d,p) transitions at deuteron energies near 80 MeV show the observables at large scattering angle to be dominated by contributions arising from the far-side of the target nucleus [1]. If the reaction is also confined to the reaction plane then the neutron transfer will take place with the maximum orbital angular momentum projection $\lambda(=\ell)$ along the normal to the reaction plane (in direction $\underline{k_d} \times \underline{k_p}$). In the case of a $j = \ell - \frac{1}{2}$ transition such reasoning leads to several identities which should be satisfied among spin-dependent reaction observables[2].

Here we consider two such relations between the vector (A_y) and tensor (A_{yy}) analysing powers and the outgoing proton polarization (P_y),

$$3P_y + 2A_{yy} + 1 = 0 \,, \tag{1}$$

$$A_{yy} + 3A_y + 2 = 0 \,, \tag{2}$$

and compare them with available reaction data. Equation (1) is an exact relation and follows from the restriction that transfer is to $\lambda = \ell$. Equation (2), on the other hand, is only approximate and is broken by both $\lambda \neq \ell$ effects and deuteron spin-flip components of the reaction amplitude. Equation (2) will be studied here in connection with the $^{116}Sn(d,p)^{117}Sn(7/2^+$, 0.71 MeV) transition at 79 MeV for which extensive A_y and A_{yy} data exist. To investigate eq. (1) requires data for the proton polarization. Data for P_y, A_{yy} and A_y have been obtained at three angles for the $^{66}Zn(d,p)$ $^{67}Zn(5/2^-$, g.s.) reaction at 88 MeV. In this case P_y could be measured as the analysing power in the time reversed reaction as both target and residual nuclei are stable. Reaction calculations for this ^{66}Zn transition show the same far-side dominance as was evident in the ^{116}Sn case[1].

We now investigate the extent to which these data on the one hand, and calculations on the other, satisfy the relations implied by far-side dominance. The calculations referred to are exact finite range calculations which include deuteron S and D-states (unless stated otherwise) and the adiabatic deuteron channel potential to incorporate S-wave breakup effects. In Fig. 1 we study the relation of eq (2) by considering the quantities A_y and $\tilde{A}_y$, where $\tilde{A}_y(=(-2-A_{yy})/3)$ is deduced from the calculated or experimental A_{yy} values. In the absence of the deuteron D-state (dashed curves) the calculated A_y and $\tilde{A}_y$ are in close agreement. In this calculation however the only mechanism for a deuteron spin-flip amplitude is the second order deuteron spin-orbit force effect. The small calculated A_y-$\tilde{A}_y$ shows that such spin-flip contributions, and the departure from $\lambda = \ell$ are small. The experimental A_y and $\tilde{A}_y$ on the other hand show significant differences. Upon inclusion of the deuteron D-state, and hence an additional spin-flip term, the calculated A_y-$\tilde{A}_y$ (solid curves) follow the trend of the data. However, the magnitude of the deviation is still underestimated by about a factor of 2. D-wave breakup effects are important for describing deuteron elastic scattering at these energies and are neglected in the present analysis. Such breakup effects are an obvious candidate for the missing spin-flip strength in this case.

In Fig. 2 we consider the relation of eq (1) be comparing P_y with $\tilde{P}_y(=(-1-2A_{yy})/3)$ for the ^{66}Zn reaction. Once again the calculated quantities P_y and $\tilde{P}_y$ are in very close agreement in the large angle region confirming the in-plane and far-side nature of the adiabatic distorted waves calculation. The data however indicate a P_y-$\tilde{P}_y$ difference of substantial magnitude which the calculation underpredicts by at least a

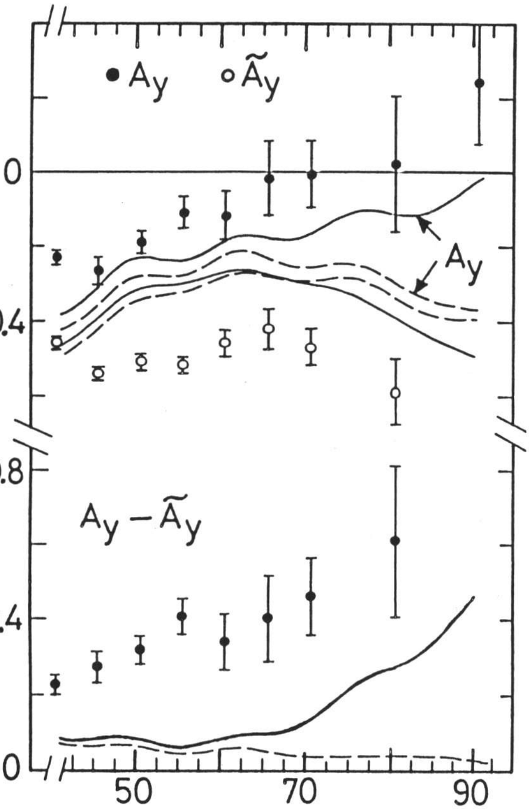

Fig. 1. Calculated and experimental A_y, $\tilde{A}_y$ and their difference for ^{116}Sn(d,p)^{117}Sn($7/2^+$, 0.71 MeV) at 79 MeV.

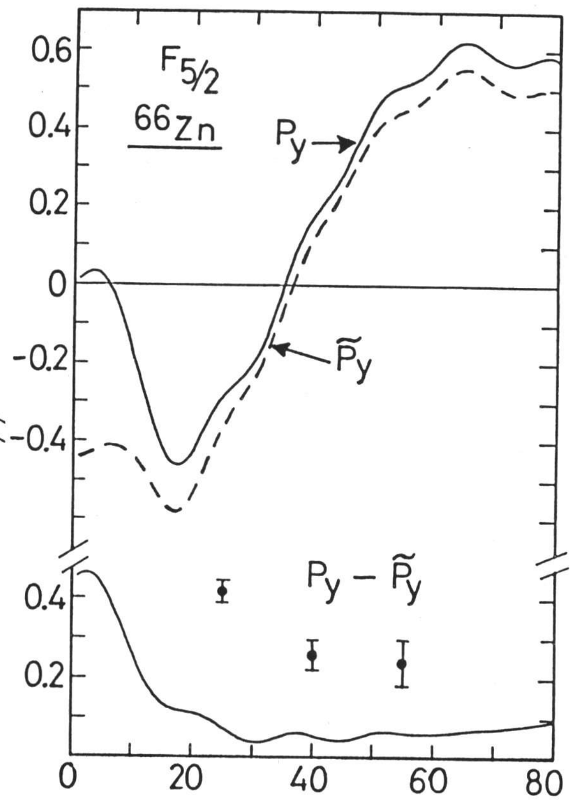

Fig. 2. Calculated P_y and $\tilde{P}_y$, their difference and the experimental difference for ^{66}Zn(d,p)^{67}Zn($5/2^-$,g.s) at 88 MeV.

factor of 3. Unlike the situation for eq. (2), we cannot appeal simply to additional deuteron spin-flip effects associated with D-wave breakup to explain this discrepancy.

We emphasise that only a mechanism which destroys the in-plane ($\lambda = \ell$) far-side dominance of the reaction can enhance the P_y-$\tilde{P}_y$ differences (Fig. 2). One possible mechanism which has been investigated in the ^{116}Sn(d,p)^{117}Sn($7/2^+$) case was to allow $d_{3/2}$ neutron transfer following excitation of the first 2^+ state in ^{116}Sn. There was no effect on the λ substate populations and negligible changes in the (d,p) observables. It appears that standard direct reaction theories consistently predict small values of P_y-$\tilde{P}_y$ at large angles independent of detailed values of parameters. It remains an open question how far refinements of the treatment of breakup effects in current theories or medium corrections are relevant to the question of far-side dominance.

References

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