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DISCLAIMER

The j-DEPENDENCE OF THE VECTOR ANALYZING POWER FOR $(d,{}^3He)$ AND (d,t) REACTIONS*

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Abstract :

Angular distributions of cross sections and vector analyzing powers were measured in the ${}^{208}Pb(\vec{d},{}^3He){}^{207}Tl$ and ${}^{208}Pb(\vec{d},t){}^{207}Pb$ reactions at 30 MeV. The vector analyzing powers show a strong j-dependence both in the $(\vec{d},{}^3He)$ and $(\vec{d},t)$ reactions. The distorted-wave Born-approximation provides qualitative fits to the data for several transitions on ${}^{208}Pb$.

We report here the results of an investigation that shows a strong j-dependence of the vector analyzing power in the ${}^{208}Pb(\vec{d},{}^3He){}^{207}Tl$ and ${}^{208}Pb(\vec{d},t){}^{207}Pb$ reactions induced with vector polarized deuterons.

A number of experiments have shown that the vector analyzing power for $(\vec{d},p)$ and $(\vec{p},d)$ reactions with polarized incident particles depends strongly on the j-value of the transferred neutron for a given orbital angular momentum transfer.[1,2] Recently, this property, along with distorted-wave Born-approximation (DWBA) fits to measured analyzing powers, has been exploited to provide spin assignments to a substantial number of states populated by these reactions in nuclei ranging from A = 40-187.[3] Also, J^{π} assignments of several states in

^{209}Pb have been confirmed with this method.[4] It has been shown that the ^{208}Pb($\vec{d}$,t)^{207}Pb neutron pickup reaction near 12 MeV, also, shows a strong j-dependence of the vector analyzing power.[4,5] Since the same states can be reached via the (p,d) reaction, either reaction can be selected, in principle, to provide J^{π} assignments for the product nuclear states.

The ($\vec{d}$,^{3}He) proton transfer reaction, of course, provides another large number of states whose J^{π} values could be assigned or confirmed if the expected similar j-dependence of the vector analyzing power were established ; and the present lack of polarized neutron beams makes the analogous ($\vec{n}$,d), experiment unfeasible. One should note that the j-dependence of polarization or vector analyzing power in proton transfer reactions has not yet been experimentally demonstrated, whereas a few (d,$\vec{n}$) and ($\vec{d}$,n) experiments have been performed.[6]

Data on the ^{208}Pb($\vec{d}$,t)^{207}Pb reaction were taken concurrently so as to extend to higher energies the study of the j-dependence in this reaction.

The experiment was performed with a 30 MeV vector polarized deuteron beam from the Berkeley 88-inch cyclotron. The target was a 0.85 mg/cm^2 ^{208}Pb foil. Left-right asymmetry data were taken simultaneously at two angles separated by 20°, using pairs of ΔE-E silicon detector telescopes . In order to eliminate instrumental asymmetries, alternate runs were taken with the spin vector of the beam oriented up and down with respect to the reaction plane. Particle identification was used to gate the ^{3}He and tritons into separate spectra. The beam polarization was monitored continuously with a polarimeter placed downstream of the main scattering chamber. The analyser used was ^{4}He, whose analyzing power in the d-^{4}He elastic scattering, measured previously,[7] was 0.974 ± 0.016 at 30 MeV and θ_L = 135°. The vector polarization of the beam was typically $p_y \simeq 0.52$.

The $(d,{}^3He)$ and (d,t) reactions populate[8] essentially the $3s_{1/2}$, $2d_{3/2}$, $1h_{11/2}$ and $2d_{5/2}$ proton hole states and the $3p_{1/2}$, $2f_{5/2}$, $3p_{3/2}$, $1i_{13/2}$, and $2f_{7/2}$ neutron hole states in ^{207}Tl and ^{207}Pb, respectively. The angular distributions of the vector analyzing power, $A_y(\theta)$, exhibit a strong j-dependence for the 2d states populated by the $(d,{}^3He)$ reaction (Fig. 1) and for the 3p and 2f states from the (d,t) reaction (fig. 2). The sign of $A_y(\theta)$ for $j = \ell + 1/2$ is opposite to that for $j = \ell - 1/2$ over most of the angular range studied, so the ease and unambiguity of j-assignment from such measurements is clearly demonstrated. Moreover, the DWBA calculation gives a good qualitative account of this effect. In the DWBA calculations shown in figs. 1 and 2, the deuteron optical potential (Table I) was generated by fitting cross sections of deuteron elastic scattering from ^{208}Pb at 27.5 MeV ;[9] the ^3He and triton optical potential parameters (Table I) were those derived by Becchetti and Greenlees[10] from a global optical-model analysis. Actually, the effect of a spin-orbit potential of 2.5 MeV in the ^3He or t channel is quite negligible both on the cross section and on the analyzing power. The magnitude of the calculated analyzing power for the transition to the $3s_{1/2}$ state is roughly proportional to the deuteron spin-orbit term ; but this term has a much smaller effect on the analyzing power for $\ell \neq 0$ states.

In summary, a strong j-dependence of the vector analyzing power in $(d,{}^3He)$ reactions has been experimentally established for $\ell = 2$ transitions in ^{208}Pb. Thus, this reaction can be used to determine spins of the many nuclear states that can be reached via proton transfer, in the same manner as has been so successful in the neutron transfer experiments.

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TABLE I

Parameters used in DWBA calculations for $^{208}Pb(d,{}^{3}He)^{207}Tl$ and $^{208}Pb(d,t)^{207}Pb$ [a].

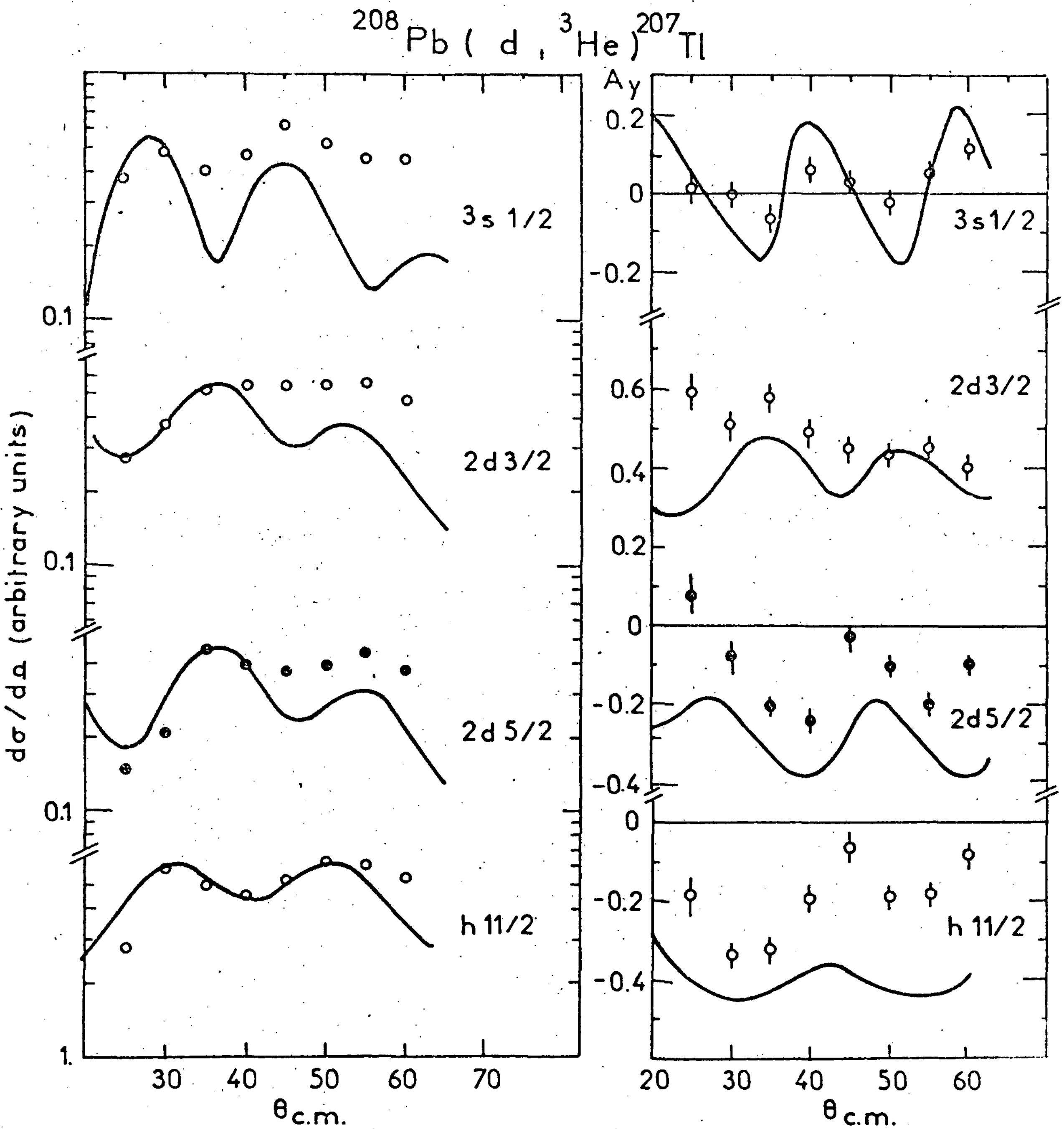
	d	^{3}He	t
V_r	84.78	158.1	159.0
r_R	1.05	1.2	1.2
a_R	0.85	0.72	0.72
W_v	0.0	42.2	13.7
W_{sF}	23.44	0.0	0.0
r_I	1.32	1.4	1.4
a_I	0.826	0.88	0.86
V_{so}	6	2.5	2.5
r_{so}	1.0	1.2	1.2
a_{so}	0.5	0.72	0.72

a) The notation is that of Ref.[10]. The transferred particle is bound in a Saxon-Woods potential with radius r = 1.25 fm, diffuseness a = 0.65 fm and spin - orbit factor λ = 25. The depth of this potential is adjusted in order to reproduce the binding energy of the bound particle.

FIGURE CAPTIONS

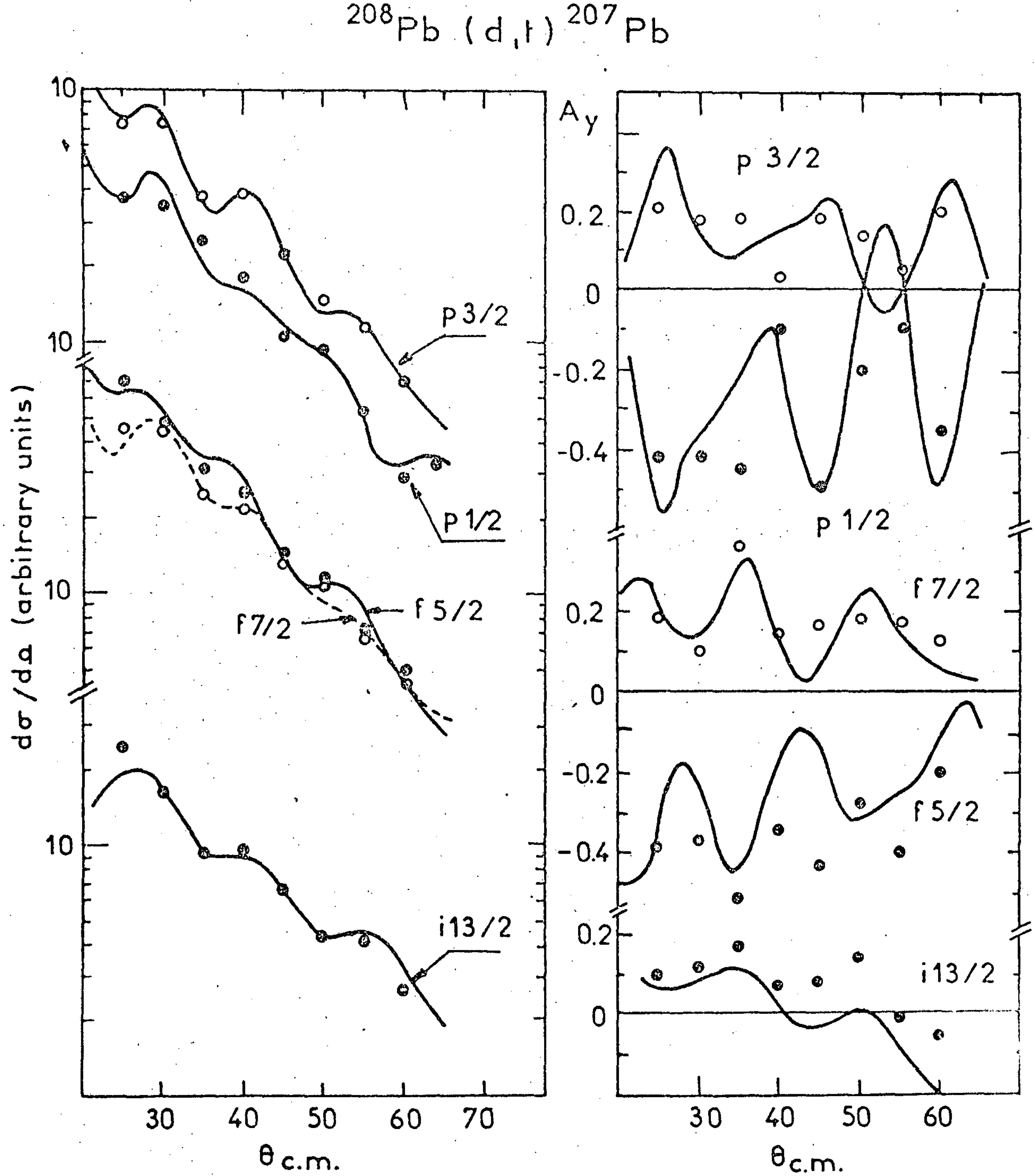
Fig. 1. Angular distributions of cross sections and vector analyzing power for the $^{208}Pb(d,^{3}He)$ ^{207}Tl reaction at 30 MeV and DWBA predictions.

Fig. 2. Angular distributions of cross sections and vector analyzing power for the $^{208}Pb(d,t)^{207}Pb$ reaction at 30 MeV and DWBA predictions.



^{208}Pb (d , ^{3}He)^{207}Tl
dσ/dΩ (arbitrary units)
A_y
3s 1/2
2d 3/2
2d 5/2
h 11/2
3s1/2
2d3/2
2d5/2
h 11/2
0.1
0.1
0.1
1.
0.2
0
-0.2
0.6
0.4
0.2
0
-0.2
-0.4
0
-0.2
-0.4
30
40
50
60
70
20
30
40
50
60
θc.m.
θc.m.

Fig. 1



208Pb (d,t) 207Pb
dσ/dΩ (arbitrary units)
10
10
10
10
p 3/2
p 1/2
f 7/2
f 5/2
i13/2
30
40
50
60
70
θ c.m.
Ay
p 3/2
p 1/2
f 7/2
f 5/2
i13/2
0.2
0
-0.2
-0.4
0.2
0
-0.2
-0.4
0.2
0
30
40
50
60
θ c.m.

Fig. 2

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