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POLARIZATION IN PROTON-DEUTERON SCATTERING AT 50 MEV[†]

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ABSTRACT

The analyzing power for 50 MeV polarized proton scattering from deuterons has been measured for center of mass angles 10 to 160 degrees. Relative uncertainties are generally less than 0.01.

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Although considerable progress in three-nucleon calculations has been made, a successful detailed reproduction of the experimental nucleon analyzing powers in $\vec{N}$-d elastic scattering has not been made.[1-4] At proton energies above 35 MeV the experimental uncertainties in the existing $\vec{p}$-d analyzing powers are such that the steadily improving quality of the predictions may soon require more precise data to test various theoretical assumptions. In particular, at 50 MeV[5,6] uncertainties of ~20% in the analyzing power occur near the negative maximum at $\theta_{c.m.} = 120°$, where calculations of both cross sections and analyzing powers are sensitive to the details of the two-nucleon $^3S_1 - ^3D_1$ tensor interaction.[2,4]

Also, since charge symmetry of nuclear forces implies equality between the nucleon analyzing powers in $\vec{p}$-d and $\vec{n}$-d scattering except for coulomb contributions, several experimental comparisons of these analyzing powers have been made at lower energies. Earlier differences between those measurements near 17 and 22 MeV have been resolved,[7,8] and the only remaining discrepancy between p-d and n-d measurements exists at 35 MeV.[9] A detailed comparison of these analyzing powers is now being undertaken[10] at 50 MeV in which the absolute uncertainties in the neutron data are ±0.07 and below. Thus, for this comparison, we have measured the $\vec{p}$-d analyzing power near 50 MeV with the considerably improved accuracy that is possible with the presently available polarized-beam intensities.

In brief, a 49.5 polarized proton beam[11] from the Berkeley 88-inch cyclotron was transported to a 36-inch scattering chamber and focussed onto a deuterium gas target cell with 0.001-inch Havar windows. The target gas and foil degraded the beam energy to 49.3 MeV at the center of the gas cell. Beam alignment in the chamber was maintained by a series of rectangular slits upstream from the chamber, immediately in front of the target, and at the exit port. Silicon charged-particle detectors were placed at equal angles on opposite sides of the beam, two on each side. Particle identification was utilized to obtain both proton and deuteron data. A double slit system limited the angular acceptance of the detectors to ±0.25° resulting in negligible finite angular corrections. Detector angles were accurate to 0.1°. A helium gas cell along with a pair of silicon detectors at equal left and right scattering angles were located in a smaller scattering chamber downstream from the main chamber to provide a continuous monitoring of the beam polarization. A 479.9 mg/cm^2 aluminum beam degrader was placed between the two chambers resulting in a 44.1 MeV beam at the polarimeter scattering center. At the polarimeter scattering angle of $\theta_L = 130°$, the p-^{4}He analyzing power was taken to be 0.87±0.02, the value calculated from p-^{4}He phase shifts interpolated between 40 MeV[12] and 48 MeV.[13] This value is 5% lower than that given by an interpolation between the experimental values at 39.8 and 45.0 MeV.[14] An examination of those data revealed that the 45.0 MeV, $\theta_L = 130°$ point was not consistent with a smooth variation of the analyzing power as a function of angle and energy. Since the 44.1 MeV calculated value at that particular angle is quite insensitive to allowable small changes in some of the phase shifts, we take it to be the more reliable result. Typical beam polarizations were 0.80 throughout the experiment. A more detailed discussion of the experimental apparatus is given in Ref. 14.

The analyzing power is given in Table 1 and plotted in Fig. 1. Quoted uncertainties are based on statistics and do not include uncertainties associated with the p-^{4}He analyzing power. Reasonable agreement with previous results [5,6] occurs for most angles except at far forward angles where a trend to lower analyzing powers occurs and in the negative maximum where larger values are obtained. The smooth curve is a theoretical prediction from Ref. 4 at 46 MeV utilizing the Reid soft core nucleon-nucleon interaction.

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TABLE 1

Analyzing power for $\vec{p}$ + D scattering at 49.3 MeV.

θ_{cm}	A	θ_{cm}	A
18.93	.123 ± .002	138.5	.078 ± .013
22.70	.133 ± .001	140.5	.143 ± .018
26.45	.145 ± .002	142.4	.148 ± .010
30.19	.154 ± .002	146.1	.176 ± .009
33.91	.153 ± .002	149.5	.198 ± .009
41.30	.187 ± .002	152.9	.151 ± .010
52.21	.162 ± .003	156.0	.144 ± .009
59.34	.118 ± .003	159.0	.095 ± .008
64.70	.070 ± .004	161.9	.090 ± .008
69.69	.015 ± .004		
74.68	−.035 ± .004		
79.67	−.116 ± .007		
84.67	−.213 ± .007		
86.35	−.238 ± .005		
89.66	−.290 ± .008		
92.64	−.345 ± .006		
94.67	−.369 ± .006		
98.71	−.430 ± .006		
99.67	−.446 ± .018		
104.55	−.504 ± .007		
107.39	−.515 ± .007		
110.2	−.517 ± .009		
112.9	−.507 ± .009		
115.5	−.524 ± .010		
120.6	−.492 ± .009		
125.5	−.376 ± .010		
130.0	−.249 ± .009		
134.4	−.060 ± .009		
136.5	.057 ± .021		

Figure 1

The $\vec{p}$ + d analyzing power at 49.3 MeV. Solid circles are the present work. The open triangles and squares are data from Refs. 5 and 6 respectively.

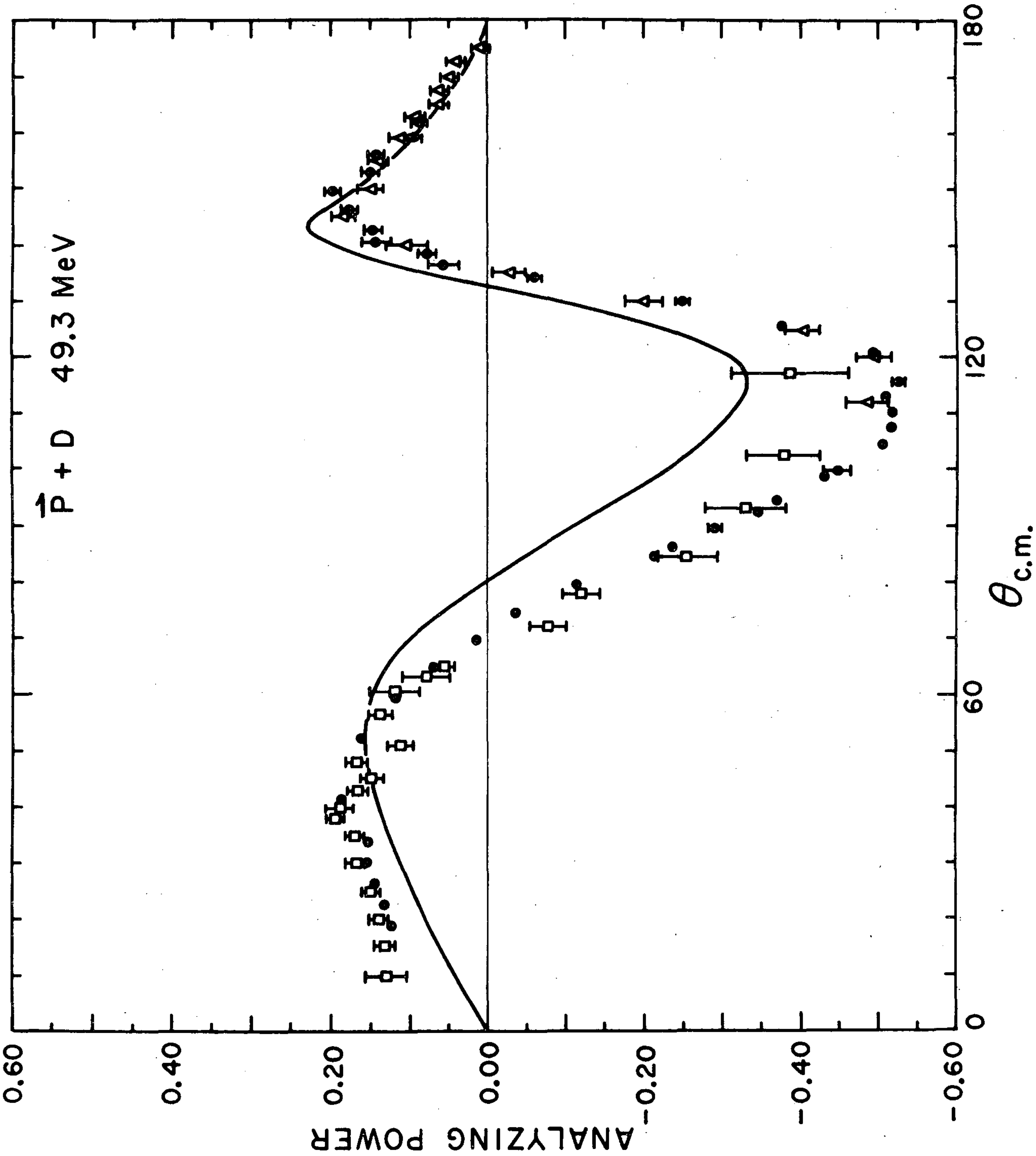
P + D 49.3 MeV
ANALYZING POWER
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
0
60
120
180
$\theta_{c.m.}$

Fig. 1

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