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AUTHOR(S): F. D. Correll, G. G. Ohlsen, Ronald E. Brown, R. A. Hardekopf, Nelson Jarmie, P. Schwandt, and P. Doleschall

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LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 87545
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TENSOR ANALYZING POWERS IN THE $^1H(\vec{d},pp)n$ REACTION AT 16 MeV
I. THE SYMMETRIC, CONSTANT-RELATIVE-ENERGY CONFIGURATIONS*

F. D. Correll, G. G. Ohlsen, Ronald E. Brown, R. A. Hardekopf
and Nelson Jarmie
Los Alamos Scientific Laboratory, Los Alamos, NM 87545 USA

P. Schwandt
Indiana University, Bloomington, IN 47401 USA

P. Doleschall
Central Research Institute for Physics, H-1525 Budapest, Hungary

Most kinematically complete three-nucleon breakup experiments are designed to explore certain limited regions of phase space where the physical observables are expected to be especially sensitive to the detailed nature of the reaction dynamics. One interesting group of kinematic configurations, which first attracted attention as a result of Faddeev calculations performed by Kloet and Tjon[1] and which were first studied experimentally by van Oers[2], are characterized by equal polar angles of the two identical, detected particles and equal relative energies between all pairs of particles. In such configurations, a single breakup amplitude is expected to be dominant,[3] and this amplitude is believed to be particularly sensitive to the short-range characteristics of the nucleon-nucleon (NN) interaction.

We have measured the tensor analyzing powers A_{xx} and A_{yz} in the $^1H(\vec{d},pp)n$ reaction at 16 MeV for a series of these "symmetric, constant-relative-energy" (SCRE) configurations. The formalism used in deriving analyzing powers from data on reactions with three particles in the final state has been described in Ref. 4, and we have adopted the symmetric choice for the y axis as described in that reference. Here, we report our experimental results and compare them with the results of recent Faddeev calculations using a separable NN potential.

Laboratory kinematic parameters for the configurations studied are listed in Table I, where quantities related to the detected protons are labelled by the subscripts 1 and 2. For each of the configurations shown, the polar angles of the protons are equal, and their azimuthal angles, which are measured from the x axis, are symmetric with respect to the y axis. The relative energy of each pair of nucleons is 1.55 MeV.

TABLE I. Laboratory kinematics of Configurations studied. Particles 1,2: protons; particle 3: neutron

α (deg)	$E_1 = E_2$ (MeV)	$\theta_1 = \theta_2$ (deg)	ϕ_1 (deg)	ϕ_2 (deg)	E_3 (MeV)
0	6.51	20.2	0.0	180.0	0.75
25	6.34	21.2	13.7	166.3	1.11
45	5.95	23.0	22.2	157.8	1.88
90	4.59	28.4	30.0	150.0	4.60
110	3.94	30.4	28.5	151.5	5.91
135	3.24	32.0	22.2	157.8	7.31
150	2.93	32.4	16.1	163.9	7.92
165	2.74	32.6	8.5	171.5	8.31
180	2.67	32.7	0.0	180.0	8.44

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All of these configurations share the property that they can be generated by a rotation of the equilateral triangle formed in the c.m. system by the relative-momentum vectors of the final-state nucleon pairs. The rotation axis is fixed in the plane of the triangle and is perpendicular to the beam direction. That configuration in which the plane of the triangle contains the beam axis and in which the proton momenta are forward directed is taken to define a rotation angle α of 0°. For this configuration, and for the one with α=180°, the corresponding laboratory geometries are coplanar; for other rotation angles, noncoplanar geometries result.

The experiments were performed by bombarding a 1.2-mg/cm^2, rotating CH_2 target with 16-MeV polarized deuterons. The target was located at the center of a large, cubical scattering chamber and was viewed by two ΔE-E solid-state detector telescopes fitted with circular collimator apertures that subtended angles of 1.5° at the target. Each telescope was mounted so that it could be rotated independently about two perpendicular axes to accommodate both coplanar and noncoplanar geometries. Beam intensities on target of 20-150 nA were used, and beam polarizations, measured using the quench-ratio technique, were typically in the range 0.75-0.80.

A slightly modified version of the three-spin-state method[5] was used to derive the analyzing powers from reaction yields measured separately with the incident deuteron beam in each of three m-states (+1, 0, -1). To minimize the effect of target deterioration upon the measured analyzing powers, the m-state sequence for the yield measurements was alternated between (+1, 0, -1) and (-1, 0, +1). The deuteron spin axis always lay in the horizontal plane and its polar angle β with respect to the beam direction was set to either 45° or 90°, depending upon the observable to be measured. The scattering chamber was also rotated about the beam axis into different orientations for measuring different observables.[4] For the two coplanar geometries, A_{xx} was measured with β=90°; for each of the noncoplanar geometries, the analyzing power combinations $A_{yz}-\frac{1}{2}A_{xx}$ and $-A_{yz}-\frac{1}{2}A_{xx}$ were measured with β=45°, and the individual analyzing powers A_{xx} and A_{yz} were extracted later.

Standard fast NIM electronics and a multiple-input CAMAC ADC were used for the data acquisition. For each event analyzed, ΔE and E signals from both telescopes and a TAC signal derived from the ΔE detectors were digitized and stored in the MODCOMP IV acquisition computer. Coincident breakup protons were mass-identified on line and their two-dimensional energy-sharing spectrum E_1 vs E_2 was constructed. The locus of kinematically allowed breakup events was clearly evident for each geometry studied. There were usually few background counts in the vicinity of the equal-proton-energy point on each locus that corresponded to the c.m. configuration of interest (the "SCRE point").

The experimental data were analyzed in increments around the kinematic loci, using a computer program that constructed circular summing bins whose centers were equally spaced around the loci and assigned to each bin the counts in those channels of the E_1 vs E_2 array that fell within its circumference and were closer to its center than to the centers of its neighbors. This procedure was applied to the individual m-state yields and the analyzing powers were calculated from the projected data.

The analyzing powers A_{xx} and A_{yz} in the region of the SCRE point on each locus studied were evaluated by averaging the data for the three nearest summing bins, and the results are plotted in Fig. 1 vs the c.m. rotation angle α. The arc length over which the data were averaged ranged from 1.8 MeV for the smallest loci ($\alpha = 110°$ and $135°$) to 4.2 MeV for the largest ($\alpha = 0°$). However, the variation of the analyzing powers around the loci was generally slow and smooth, so that this procedure is believed to have reduced the statistical uncertainties in the quoted analyzing powers without significantly affecting their numerical values. Also shown in Fig. 1 are the predictions for these quantities from some recent Faddeev calculations made with a rather complete separable NN interaction.[6] In general, the agreement between the measured and calculated values seems fairly good, although there is some evidence that the measured values of A_{yz} tend to be slightly smaller than the calculations predict, whereas for A_{xx} the opposite appears to be true.

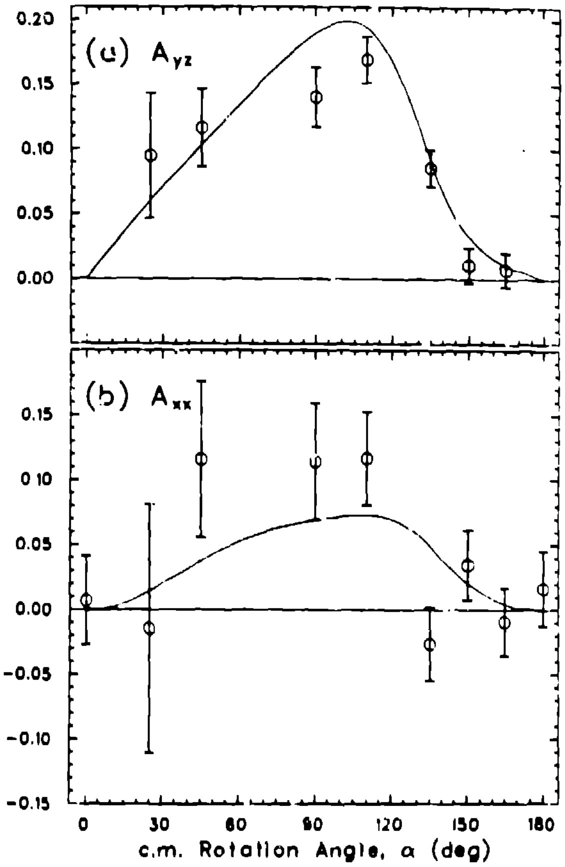

Fig. 1. Tensor Analyzing Powers A_{yz}, A_{xx} vs cm Rotation Angle, α. Dots: data; Curves: Faddeev calculations with S,P,D and $^3S_1-^3D_1$.

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