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Analyzing Power for d-^{4}He Elastic Scattering at 12.0, 14.0, and 17.0 MeV*

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Angular distributions of the analyzing tensors for d-^{4}He elastic scattering in the angular range 30–145° (c.m.) and at 12, 14, and 17 MeV are presented. An over-all absolute precision of about ±0.01 is obtained. In addition to the complete angular distributions, data were taken in a fine mesh near 12 MeV, 37° (lab), where the analyzing tensor A_{yy} apparently approaches unity. The manner in which it can be decided whether or not A_{yy} goes to exactly unity is discussed. If this is found to be the case, a valuable absolute polarization standard will be available.

INTRODUCTION

d-α elastic scattering offers one of the most direct means for learning about the structure and levels of the ^{6}Li nucleus. In addition, since the phase shifts which describe the interaction vary only slowly with energy,[1] and since the polarization effects are large, the process has assumed considerable importance as a means of intercalibration of data obtained at various polarized-beam facilities.

In the present paper, we report angular distributions of the four analyzing tensors for d-^{4}He elastic scattering at 12.0, 14.0, and 17.0 MeV. The data reported are absolute within the quoted errors.

There have been several previous measurements of d-α polarization parameters. The most recent and complete data is that of the Zurich group,[2–5] in which angular distributions of all four analyzing tensors were measured at many energies in the range 3–11.5 MeV. On the high-energy side of the present data, measurements of three of the four tensors in the range 17.7–21.4 MeV have been obtained by Arvieux *et al.*[6] For a complete and recent list of previous experiments, see the review article by Ajzenberg-Selove and Lauritson.[7]

There are many experimental problems associated with obtaining high quality analyzing power data for spin-1 projectiles, many of which either do not occur or are less serious in the case of spin-$\frac{1}{2}$ projectiles. This article will discuss the problems of this type which were studied during the acquisition of the present data.

EXPERIMENTAL DETAILS

A beam of 75–100-keV longitudinally polarized deuterons was provided by the Los Alamos Scientific Laboratory (LASL) Lamb-shift source.[8] A crossed field analyzer was used to precess the deuteron spin in the horizontal plane, so that the spin angle β ($\cos\beta = \hat{s}\cdot\hat{k}$, where $\hat{s}$ is a unit vector along the polarization symmetry axis and $\hat{k}$ is the beam direction) at the target was as desired. Spin angles of $\beta = 45$, 54.7, and 90° were used during various portions of the data collection. The polarized beam was accelerated to 12–17 MeV with the LASL FN tandem accelerator.

An over-all plan view of the accelerator arrangement is shown in Fig. 1. For the beam line used (switching magnet 45° position) the spin angle β with the spin precessor turned off is 88.2°. The spin precessor calibrations were determined by the up-down asymmetry of d-α scattering. The spin angle settings so obtained are accurate and reproducible to about ±0.5°. The limiting precision on the spin angle is believed to arise from "spin aberrations," i.e., from unwanted precession of the spin by the various ion-optical elements. These effects depend on the orbit of the beam through a particular device, and are especially severe for the entrance or exit of a bending magnet.[9, 10]

Beam Polarization Determinations

The beam polarization was determined by the quench ratio method[11] on the analyzer cup (see Fig. 1). For deuterons, this method is less reliable at the present time than it is for protons, where 0.4% absolute accuracy has been obtained under the best conditions, and where about 1% absolute accuracy is routinely obtained. About 2% accuracy is routinely obtained for deuterons, and is assumed here.

There are two main sources of error which presently limit the accuracy of the quench ratio method. First, depolarization in the tandem terminal, which arises from the residual gas, is a significant effect. For a ^{2}H$^-$ ion which is prematurely stripped to a $^2H^0$ (neutral) atom before the stripper foil, one expects[12] a depolarization of $\frac{2}{7}$ for the vector polarization (p_Z) and $\frac{2}{3}$ for the tensor polarization (p_{ZZ}). A measurement with deuterons at 10 MeV, i.e., with 5 MV on the tandem terminal, indicated a tensor depolarization of about 1.5% for the prevailing pressure in the tandem terminal, corresponding to about 2.3% of the $^2H^-$ ions being prematurely stripped. This can be used to estimate the depolarization at other energies by assuming that the effects vary as the reciprocal of the ion velocity, as is expected for atomic charge exchange collisions at these energies.[13] A graph of the expected depolarization as a function of energy, based on this assumption, is presented in Fig. 2. Proton depolarization, as estimated from the same datum, is also shown. This effect can be removed by providing adequate pumping in the tandem terminal; no terminal pump was available to us during the present experiment.

The depolarization measurement discussed above was made as follows. The second-rank beam polarization was first measured, by d-α scattering, under normal conditions. The stripper foil was then removed and the current still reaching the analyzer cup was measured (105 pA). Additional gas (O_2) was then let into the stripper foil region (no strippper tube in place) until the analyzer cup current reached 4.2 nA. Since the current should vary as the square of the stripper region pressure for a two-step process ($^2H^- \rightarrow {}^2H^0$ followed by $^2H^0 \rightarrow {}^2H^+$) this indicated that the pressure was increased by a factor of 6.4 by this operation. The stripper foil was then replaced, and the tensor polarization of the beam was again measured, and found to be $9.7 \pm 1\%$ lower than the initial value. Since the depolarization should vary linearly with the pressure, this gives the quoted result of ~1.5% for the depolarization under the usual vacuum conditions. Since the vacuum conditions in the accelerator are somewhat variable, depending on recent history, this can be a serious source of scatter of data taken at different times, particularly for energies lower than 10 MeV.

The second effect is associated with the "polarization enhancement by beam scraping." This arises from the fact that the unpolarized component of the beam is of lower ion-optical quality than the polarized part, and hence is preferentially rejected at each slit or aperture. Ideally, then, one wishes to measure the quench ratio on target. We have been able to obtain stable readings, however, no further downstream than the analyzer cup. The polarization enhancement between the analyzer cup and target is believed to be of the order of 1%. This estimate is obtained as follows. The effect should be 2 to $2\frac{1}{2}$ times worse for deuteron beams than for proton beams, since the unpolarized fraction of the beam is 2 to $2\frac{1}{2}$ times larger in that case, and an estimate of 0.4% has been obtained for protons.[11] The proton effect was estimated by comparing the on-target quench ratio to the (relatively stable) analyzer-cup quench ratio many times. This effect, too, probably increases for lower beam energies since the system transmission then falls. This error can possibly be removed either by improved machine energy regulation or by a rapid (pulsed) measurement of the quench ratio.[14]

The quenched beam is actually slightly polar-

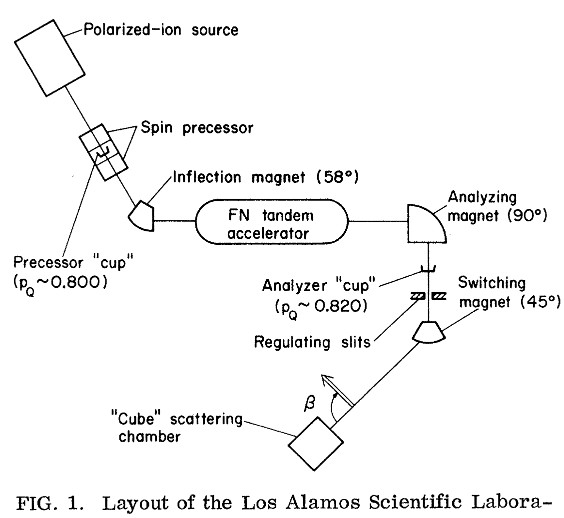

FIG. 1. Layout of the Los Alamos Scientific Laboratory source-accelerator system, showing the position of the analyzer cup which was used for the quench ratio measurements. p_Q is the fraction of the beam which is polarized in the selected state.

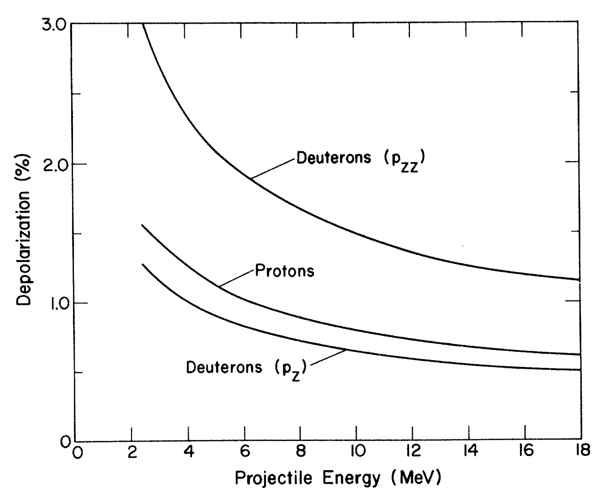

FIG. 2. Vector and tensor depolarization for deuterons, and vector depolarization for protons, which occurs via the residual gas in the tandem terminal.

ized. This results in a small (known) correction to the value of the polarization one calculates from the raw quench ratio. The correction amounts to $\pm 0.4 \pm 0.1\%$ for p_{ZZ} and to $-0.1 \pm 0.1\%$ for p_Z. See Ref. 9 for a discussion of this correction.

In summary, the quench ratio raw result should be corrected by a variable amount. However, the two largest effects cancel to a very large extent. For the present work, we apply no correction to the observed quench ratio determinations of beam polarization, and designate an uncertainty of ±2% for the values so obtained. This uncertainty may be regarded as chiefly a scale error.

The methods used for analyzing power determinations require a knowledge of the polarization of the beam in each of the three spin substates used. The values characteristic of the $m_I = 1$ substate are $p_Z = 1, p_{ZZ} = 1$; those of the "$m_I = 0$" substate are $p_Z = 0, p_{ZZ} = -1.966$; and those of the "$m_I = -1$" substate are $p_Z = -0.984, p_{ZZ} = 0.952$. The quotation marks indicate that the selected states, except the $m_I = 1$ state, are not quite ideally pure. Often the state $m_I = 1$ with the ionizer fields reversed was used in lieu of the $m_I = -1$ state; for this state we have $p_Z = -1$ and $p_{ZZ} = 1$. The raw quench ratio measures the fraction of the beam in the selected substate, the remainder being assumed unpolarized. The relative values of p_Z and p_{ZZ} that are given above are calculated on the basis of a 60 G ionizer field in the polarized source; experimental verification of these values has been made only to ~0.5%. However, a change in the ionizer field of ~5% would change the quoted value, even in the most sensitive cases, by somewhat less than 0.5%.

Experimental Method

A 30.5-cm inside dimension cube-shaped scattering chamber which allowed simultaneous detection of particles scattered in the horizontal and vertical planes was used. The methods which were used are described in detail in Ref. 15 under the titles "Ratio Method" and "Three Spin State Method." Each of these methods yields the observables A_{xx}, A_{yy}, A_y, and A_{xz} rather than the customarily reported set $\frac{1}{2}(A_{xx} - A_{yy})$, A_{zz}, A_y, and A_{xz}.

The cube was filled with ^{4}He gas at 1 atm for the measurements. The scattering geometry is summarized as follows: width of front and rear slits is 1.02 mm; height of rear slit is 9.5 mm; separation between slits is 58.6 mm; target center to rear slit distance is 92.1 mm; slit thickness (brass) is 0.5 mm; and angular resolution [full width at half maximum (FWHM)] is ~1°.
The beam current was balanced on the front and rear horizontal and vertical slits of the chamber. In the case of the ratio method, where a 180° rotation of the chamber is involved, the condition for a "proper flip"[15] was required—that is, the fraction of the total current appearing on each slit jaw was required to be the same before and after the rotation. This condition was sought manually. That is, beam steering adjustment was made until rotation of the cube did not change the balance. (It should be noted that one does not require the slit currents to be equal.) No beam steering adjustments were made after the initiation of a data cycle. In the case of the three spin state method, no rotation of the apparatus is involved, and the beam steering adjustment is therefore less critical. The stability of the slit current balance is one of the chief factors which limited the accuracy of the experiment, especially in view of the rather small geometry which was employed.

The rear slits are an integral part of the Faraday cup, so that the slit current indicating device must subsequently sum the currents and deliver the sum to a standard current integrator. This was accomplished with a locally made circuit.

The computer program used for these measurements controls all of the required functions automatically. Depending on the method, three or four separate counting periods are involved for a measurement. The beam polarization is measured for each counting period and the arithmetic average is used in the computation of the analyzing tensors.

RESULTS

Data were taken at 12.0, 14.0, and 17.0 MeV. A composite graph of the data is presented in Fig. 3. The conventional combinations $\frac{1}{2}(A_{xx} - A_{yy})$ ($\equiv \sqrt{3}\, T_{22}$ in the spherical notation) and A_{zz} ($\equiv \sqrt{2}\, T_{20}$ in the spherical notation) are plotted even though these are not the quantities directly measured. The measured quantities, A_{xx} and A_{yy}, are given in tabular form in Tables I–III. The errors quoted in the tables are statistical only.

Translation between the various representations is accomplished by use of the identity

$$A_{xx} + A_{yy} + A_{zz} = 0,$$

from which it follows that

$$A_{xx} = \tfrac{1}{2}(A_{xx} - A_{yy}) - \tfrac{1}{2} A_{zz} \equiv \sqrt{3}\, T_{22} - \frac{1}{\sqrt{2}} T_{20},$$

$$A_{yy} = -\tfrac{1}{2}(A_{xx} - A_{yy}) - \tfrac{1}{2} A_{zz} \equiv -\sqrt{3}\, T_{22} - \frac{1}{\sqrt{2}} T_{20}.$$

A_y and A_{xz} are related to spherical equivalents merely by scale factors:

$$A_y = \frac{2}{\sqrt{3}}\, i T_{11},$$

$$A_{xz} = -\sqrt{3}\, T_{21}.$$

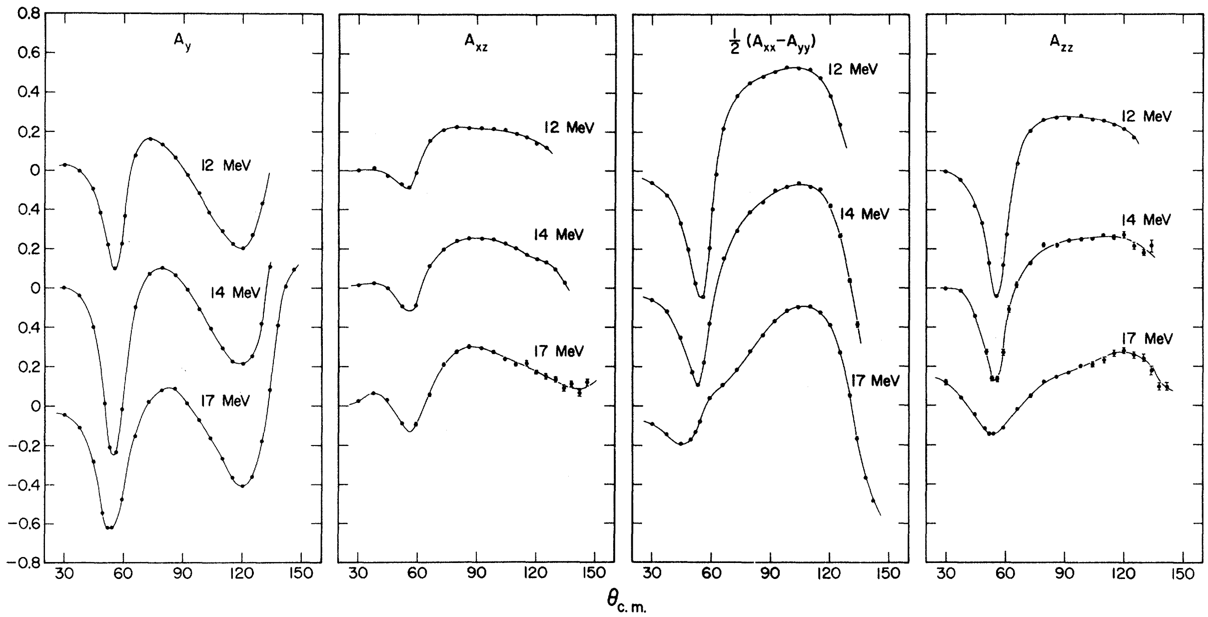

FIG. 3. Observed angular distributions of the analyzing tensors A_y, A_{xz}, $\frac{1}{2}(A_{xx}-A_{yy})$, and A_{zz} at 12, 14, and 17 MeV.

For the experimental techniques used here, use of the Cartesian tensors A_{xx} and A_{yy} has the advantage that each of the reported quantities is independently measured, whereas the quantities $\frac{1}{2}(A_{xx}-A_{yy})$ and A_{zz} each depend on two measurements.

It is difficult to evalute the systematic errors in an experiment of this type. The known sources of error are as follows:

Imprecise current integration. A problem with current integration is especially likely at small angles ($\theta_{\rm lab} < 30°$) where small (~1 nA) beam currents were used. The methods employed here each depend on current integration. (The "Current Integration Free Method" of Ref. 15 was used for certain consistency checks which are not in-

TABLE I. ^{4}He($\vec{d}$,d)^{4}He analyzing powers at 12.00 MeV.

$\theta_{\rm lab}$	$\theta_{\rm c.m.}$	A_y	A_{xz}	A_{xx}	A_{yy}
20	29.9	0.024 ± 0.004	0.006 ± 0.006	−0.052 ± 0.006	0.052 ± 0.006
25	37.3	−0.003 ± 0.004	0.015 ± 0.009	−0.104 ± 0.006	0.150 ± 0.006
30	44.6	−0.098 ± 0.004	−0.026 ± 0.005	−0.178 ± 0.007	0.362 ± 0.006
32.5	48.2	−0.216 ± 0.006		−0.267 ± 0.004	0.537 ± 0.004
35	51.8	−0.379 ± 0.006	−0.071 ± 0.009	−0.338 ± 0.005	0.814 ± 0.003
37.5	55.3	−0.501 ± 0.003	−0.086 ± 0.013	−0.324 ± 0.005	0.971 ± 0.003
40	58.9	−0.373 ± 0.007	−0.015 ± 0.013	−0.153 ± 0.006	0.638 ± 0.004
41.2	60.5	−0.235 ± 0.011		−0.033 ± 0.007	0.363 ± 0.006
45	65.8	0.073 ± 0.007	0.153 ± 0.008	0.196 ± 0.005	−0.232 ± 0.005
50	72.7	0.159 ± 0.006	0.208 ± 0.006	0.287 ± 0.004	−0.487 ± 0.005
55	79.3	0.131 ± 0.005	0.222 ± 0.005	0.322 ± 0.003	−0.580 ± 0.004
60	85.8	0.063 ± 0.005	0.221 ± 0.003	0.352 ± 0.003	−0.620 ± 0.004
65	92.1	−0.026 ± 0.004	0.218 ± 0.003	0.374 ± 0.003	−0.641 ± 0.003
70	98.2	−0.117 ± 0.005	0.214 ± 0.003	0.391 ± 0.003	−0.669 ± 0.004
75	104.1	−0.216 ± 0.005	0.208 ± 0.003	0.398 ± 0.004	−0.657 ± 0.005
80	109.7	−0.309 ± 0.005	0.189 ± 0.003	0.392 ± 0.003	−0.644 ± 0.005
85	115.1	−0.374 ± 0.006	0.171 ± 0.004	0.357 ± 0.004	−0.589 ± 0.005
90	120.2	−0.398 ± 0.007	0.141 ± 0.005	0.276 ± 0.005	−0.489 ± 0.006
95	125.1	−0.331 ± 0.008	0.118 ± 0.006	0.144 ± 0.005	−0.311 ± 0.006

TABLE II. ^{4}He($\vec{d}$,d)^{4}He analyzing powers at 14.00 MeV.

θ_{lab}	$\theta_{c.m.}$	A_y	A_{xz}	A_{xx}	A_{yy}
20	29.9	0.000 ± 0.003	0.015 ± 0.003	−0.057 ± 0.006	0.063 ± 0.006
25	37.3	−0.040 ± 0.004	0.025 ± 0.003	−0.111 ± 0.006	0.125 ± 0.006
30	44.6	−0.202 ± 0.005	0.002 ± 0.004	−0.181 ± 0.008	0.325 ± 0.008
34	50.3	−0.587 ± 0.006		−0.264 ± 0.010	0.592 ± 0.007
35	51.8		−0.092 ± 0.006		
36	53.2	−0.811 ± 0.006		−0.262 ± 0.012	0.727 ± 0.008
38	56.1	−0.838 ± 0.006		−0.152 ± 0.013	0.620 ± 0.010
40	58.9	−0.621 ± 0.007	−0.089 ± 0.007	−0.022 ± 0.012	0.351 ± 0.010
45	65.8	−0.101 ± 0.006	0.111 ± 0.005	0.144 ± 0.009	−0.158 ± 0.010
50	72.7	0.072 ± 0.005	0.194 ± 0.004	0.228 ± 0.007	−0.351 ± 0.008
55	79.3	0.102 ± 0.004	0.239 ± 0.004	0.278 ± 0.006	−0.493 ± 0.008
60	85.8	0.065 ± 0.004	0.252 ± 0.004	0.328 ± 0.006	−0.543 ± 0.007
65	92.1	−0.010 ± 0.004	0.249 ± 0.004	0.375 ± 0.006	−0.614 ± 0.007
70	98.2	−0.109 ± 0.004	0.250 ± 0.004	0.392 ± 0.006	−0.636 ± 0.008
75	104.1	−0.208 ± 0.004	0.228 ± 0.004	0.410 ± 0.006	−0.658 ± 0.008
80	109.7	−0.304 ± 0.005	0.206 ± 0.004	0.382 ± 0.007	−0.648 ± 0.009
85	115.1	−0.375 ± 0.005	0.168 ± 0.005	0.380 ± 0.008	−0.632 ± 0.011
90	120.2	−0.387 ± 0.006	0.144 ± 0.005	0.283 ± 0.010	−0.553 ± 0.012
95	125.1	−0.350 ± 0.007	0.136 ± 0.006	0.160 ± 0.012	−0.373 ± 0.014
100	129.7	−0.185 ± 0.010	0.094 ± 0.005	−0.051 ± 0.015	−0.122 ± 0.015

cluded in the tables.)

Spin angle uncertainty. For the data quoted, where either $\beta = 45°$ or $\beta = 90°$ was used, the results are independent of first-order spin misalignment, so this uncertainty is not important in the present case.

Beam position stability. Because of the small geometry employed, this is probably the most serious limitation of the present experiment. The effects of beam wander are erratic and can only

TABLE III. ^{4}He($\vec{d}$,d)^{4}He analyzing powers at 17.00 MeV.

θ_{lab}	$\theta_{c.m.}$	A_y	A_{xz}	A_{xx}	A_{yy}
20	29.9	−0.048 ± 0.006	0.025 ± 0.009	−0.147 ± 0.009	0.030 ± 0.008
25	37.3	−0.091 ± 0.005	0.065 ± 0.009	−0.166 ± 0.008	0.128 ± 0.007
30	44.6	−0.287 ± 0.006	0.029 ± 0.009	−0.174 ± 0.008	0.219 ± 0.007
33.5	49.6	−0.543 ± 0.005		−0.116 ± 0.008	0.233 ± 0.007
35	51.8	−0.623 ± 0.005	−0.091 ± 0.009	−0.062 ± 0.008	0.207 ± 0.007
36.5	53.9	−0.620 ± 0.005		−0.011 ± 0.008	0.153 ± 0.008
40	58.9	−0.481 ± 0.005	−0.097 ± 0.008	0.099 ± 0.008	0.015 ± 0.008
45	65.9	−0.155 ± 0.006	0.056 ± 0.010	0.116 ± 0.009	−0.094 ± 0.009
50	72.7	0.011 ± 0.007	0.208 ± 0.009	0.157 ± 0.008	−0.207 ± 0.009
55	79.4	0.079 ± 0.005	0.273 ± 0.009	0.217 ± 0.008	−0.337 ± 0.009
60	85.8	0.086 ± 0.005	0.300 ± 0.008	0.289 ± 0.007	−0.423 ± 0.009
65	92.1	0.009 ± 0.005	0.294 ± 0.008	0.347 ± 0.007	−0.514 ± 0.009
70	98.2	−0.074 ± 0.005	0.272 ± 0.008	0.378 ± 0.007	−0.581 ± 0.009
75	104.1	−0.166 ± 0.006	0.239 ± 0.009	0.396 ± 0.008	−0.604 ± 0.010
80	109.7	−0.268 ± 0.006	0.211 ± 0.010	0.388 ± 0.009	−0.618 ± 0.012
85	115.1	−0.367 ± 0.006	0.214 ± 0.013	0.342 ± 0.010	−0.605 ± 0.013
90	120.2	−0.410 ± 0.005	0.169 ± 0.009	0.272 ± 0.009	−0.550 ± 0.011
95	125.1	−0.362 ± 0.007	0.150 ± 0.011	0.144 ± 0.011	−0.398 ± 0.013
100	129.7	−0.179 ± 0.009	0.133 ± 0.014	−0.067 ± 0.014	−0.172 ± 0.014
105	134.1	0.078 ± 0.011	0.088 ± 0.017	−0.258 ± 0.016	0.081 ± 0.015
110	138.2	0.406 ± 0.010	0.112 ± 0.015	−0.413 ± 0.016	0.320 ± 0.013
115	142.1	0.606 ± 0.009	0.064 ± 0.016	−0.533 ± 0.015	0.438 ± 0.012

be estimated from the scatter of the data.

Uncertainty in the beam polarization. This was previously discussed.

Taking these effects together, the accuracy of the experiment is considered to be limited by the largest of the following:
(1) ±0.01 for A_y, A_{yy}, and A_x and ±0.02 for A_{xz};
(2) ± quoted statistics;
(3) ±2% of the analyzing tensor value.
Effects 1 and 2 are of the nature of random fluctuations, while effect 3 is primarily a scale error, as previously discussed.

The value of A_{yy} at 12 MeV, 37° is particularly interesting in that it appears to be approaching a maximum possible value. This observation stimulated us to map the value of A_{yy} over this region rather extensively. The results are given in Table IV. The maximum value is in the range 11.6–12.2 MeV and at an indicated angle between 37.1 and 37.4°. The quality of the present data is not sufficient to fix the point at which the maximum occurs more accurately.

Our motivation for a search for an $A_{yy}=1$ point arose from the proof of an existence theorem for an $A_y=1$ point in p-^{4}He elastic scattering,[16] and our recognition that a similar proof could be made in the present case, as follows. The scattering matrix M for scattering of a spin-1 projectile by a spinless target has the form

$$M=\begin{pmatrix} A & C & E \\ -D & B & D \\ E & -C & A \end{pmatrix},$$

where the spins of both the incident and outgoing spin-1 particles are described in the projectile helicity frame (i.e., in a frame with z axis along the projectile direction of motion, $\vec{k}_{\text{in}}\times\vec{k}_{\text{out}}$). (Time reversal invariance can be used to reduce the five elements to four, but this is not necessary for the present arguments.) The analyzing tensor A_{yy} is given by

$$A_{yy}=\frac{\mathrm{Tr}M\mathcal{P}_{yy}M^\dagger}{\mathrm{Tr}MM^\dagger},$$

where

$$\mathcal{P}_{yy}=3S_yS_y-2I\equiv\tfrac{1}{2}\begin{pmatrix} -1 & 0 & -3 \\ 0 & 2 & 0 \\ -3 & 0 & -1 \end{pmatrix};$$

S_y is one of the standard spin-1 angular momentum matrices. Trivial algebraic manipulation then shows that $A_{yy}=1$ if and only if $A=-E$. If one performs a phase-shift analysis of the available data at a given energy E_1, one may plot the calculated quantity E/A in the complex plane, with the center-of-mass scattering angle as a parameter. Suppose that the closed contour so defined excludes the point $E/A=-1$. Then suppose that a similar analysis of data at the energy E_2 produces a contour which includes the point $E/A=-1$. It then follows from continuity that, at some energy between E_1 and E_2, $E/A\equiv-1$ and hence $A_{yy}\equiv1$. The experimentalist's problem then is to locate the maximum value rather than to prove that it is unity—an experimental problem at least an order of magnitude simpler. One assumes in the above argument that the phase shifts are at least approximately correct, but they need not be accurately known. Polarization transfer data[17] is thus

TABLE IV. ^{4}He$(\vec{d},d)^4$He analyzing power.

Deuteron energy (MeV)	θ_{lab}	A_{yy}
11.6	36.5	0.941 ± 0.020
11.6	37.5	1.011 ± 0.020
11.6	38.5	0.916 ± 0.025
11.8	36.5	0.978 ± 0.020
11.8	37.5	1.011 ± 0.020
11.8	38.5	0.920 ± 0.025
12.0	35.5	0.702 ± 0.025
12.0	36.5	0.988 ± 0.020
12.0	37.5	1.015 ± 0.021
12.0	38.5	0.932 ± 0.024
12.0	39.5	0.737 ± 0.031
12.2	35.5	0.880 ± 0.021
12.2	36.5	0.972 ± 0.021
12.2	37.3	0.983 ± 0.015
12.2	37.5	0.996 ± 0.022
12.2	37.7	0.986 ± 0.015
12.2	38.5	0.926 ± 0.026
12.2	39.5	0.738 ± 0.027
12.7	36.0	0.937 ± 0.005
12.7	37.0	0.968 ± 0.005
12.7	38.0	0.894 ± 0.006
13.0	35.0	0.673 ± 0.006
13.0	36.0	0.889 ± 0.005
13.0	37.0	0.899 ± 0.006
13.0	38.0	0.835 ± 0.006
13.0	40.0	0.488 ± 0.010
14.0	34.0	0.592 ± 0.007
14.0	36.0	0.727 ± 0.008
14.0	38.0	0.620 ± 0.010
14.0	40.0	0.351 ± 0.010
14.0	42.0	0.041 ± 0.011
17.0	33.5	0.233 ± 0.007
17.0	35.0	0.207 ± 0.007
17.0	36.5	0.153 ± 0.008
17.0	40.0	0.015 ± 0.008
17.5	35.0	0.147 ± 0.012
17.5	36.0	0.089 ± 0.012

of interest in proving that one is indeed in the right region of parameter space. The matter of determining whether or not the correct solution has been found is discussed further in Ref. 18.

The extremely large values of A_y near 14 MeV, 37°, is also of interest as a calibration value. A search of this angular vicinity with 13.5- and 14.5-MeV deuteron-beam energies revealed that a local minimum occurs near 14 MeV. It should be noted in this connection that no finite geometry correction has been applied to the data of Tables I–IV, and that corrections as large as 0.01 at the sharp minimum in A_y at 14 MeV are indicated by comparison of data taken with 1° and with 2° FWHM angular resolution.

Comparison of the present data with a smooth extrapolation of the 3–11.5-MeV data of Refs. 2–4 gives reasonable agreement. However, the measurements of "P" ($\equiv -\frac{1}{2}A_y$), "Q" ($\equiv -\frac{1}{2}A_{yy}$), and "$R$" ($\equiv -\frac{1}{2}A_{xx}$) of Ref. 6 appear inconsistent with the trends indicated by the present data. The parameters Q and R, in particular, disagree with an extrapolation of the present data by as much as a factor of 2.

CONCLUSION

Very large polarization effects prevail in d-^{4}He elastic scattering up to 17 MeV. However, at 17 MeV there is evidence that "washing out" of the polarization effects may be beginning to occur. The point at 12 MeV, 37°, appears to be useful for absolute polarization monitoring of the second-rank polarization of a deuteron beam, while the point at 14 MeV, 37° appears to be excellent for relative vector polarization monitoring of a deuteron beam.

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