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# POINTS OF MAXIMUM POLARIZATION EFFICIENCY IN $^4He(\vec{d}, d)\,^4He$

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# POINTS OF MAXIMUM POLARIZATION EFFICIENCY IN $^4He(\vec{d},d)^4He$*

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Several points $(E_i,\Theta_i)$ of maximum possible analyzing power have recently been identified in d-$^4$He elastic scattering. From an analysis of data between 3 and 17 MeV, three points with $A_{yy} = 1$ were found below 12 MeV and another with $A_y = -1$ may exist above that energy[1]. An experimental indication that extreme values of the analyzing power $A_y$ may occur comes from measurements near $E_d = 28$ MeV and $\Theta_{cm} \simeq 154°$, where $A_y \simeq A_{yy} \simeq 1$ [2].

Reaching an extreme value of some component of the analyzing power imposes certain conditions on the elements of the transition matrix M. In the parametrization of Ohlsen et al.[3]

$$M = \frac{1}{2}\begin{pmatrix} A-B & \sqrt{2}\,D & -A-B \\ -\sqrt{2}\,D & 2\,C & \sqrt{2}\,D \\ -A-B & -\sqrt{2}\,D & A-B \end{pmatrix},$$

an extreme value of $A_{yy} = 1$ requires B = 0. For an extreme value $A_y = \pm 1$, however, $A = C = \pm iD$ and B = 0 is necessary. Thus $A_{yy} = 1$ is a prerequisite for $A_y = \pm 1$ [1,4], and both components must peak at the same critical point $(E_i,\Theta_i)$. A definite identification of points with extreme values of the analyzing power can be carried out by using a phase-shift analysis to compute the amplitudes A through D and to verify the validity of the relevant conditions[1]. In an alternate approach[5] these conditions are introduced into the formulae for the observables[3] and can then be checked experimentally. The requirement B = 0 for $A_{yy} = 1$ yields

$$A_{yy} = P^{y'y'} = K_{yy}^{y'y'} = 1 \tag{1}$$

$$A_{xx} = P^{x'x'} = K_{yy}^{x'x'} = K_{xx}^{y'y'} \tag{2}$$

$$A_{zz} = P^{z'z'} = K_{zz}^{y'y'} = K_{yy}^{z'z'} \tag{3}$$

$$K_x^{x'} = K_z^{x'} = K_{xy}^{x'} = K_{yz}^{x'} = 0 \tag{4}$$

$$K_x^{z'} = K_z^{z'} = K_{xy}^{z'} = K_{yz}^{z'} = 0 \tag{5}$$

$$K_x^{x'y'} = K_z^{x'y'} = K_{xy}^{x'y'} = K_{yz}^{x'y'} = 0 \tag{6}$$

$$K_x^{y'z'} = K_z^{y'z'} = K_{xy}^{y'z'} = K_{yz}^{y'z'} = 0\,. \tag{7}$$

Eqs. (4) to (7) are particularly important, since a value of zero at $(E_i,\Theta_i)$ does not depend on the calibration of any polarizations. For an extreme value $A = \pm 1$, the relative values of all M-matrix elements are determined and the common constant is given by the cross section $\sigma_o$ at $(E_i,\Theta_i)$. Thus all 51 polarization observables are numerically determined, and in addition to eqs. (4) to (7) the following conditions hold

$$A_y = P^{y'} = K_y^{y'y'} = K_{yy}^{y'} = \pm 1 \tag{8}$$

$$A_{yy} = P^{y'y'} = K_y^{y'} = K_{yy}^{y'y'} = 1 \quad (9)$$

$$A_{xz} = P^{x'z'} = K_{xz}^{x'z'} = 0 \quad (10)$$

$$K_{xz}^{y'} = K_{xz}^{x'x'} = K_{xz}^{y'y'} = K_{xz}^{z'z'} = 0 \quad (11)$$

$$K_y^{x'z'} = K_{xx}^{x'z'} = K_{yy}^{x'z'} = K_{zz}^{x'z'} = 0 \quad (12)$$

$$K_y^{z'z'} = K_{zz}^{y'} = K_y^{x'x'} = K_{xx}^{y'} = \mp 1/2 \quad (13)$$

$$K_{zz}^{z'z'} = K_{xx}^{z'z'} = K_{zz}^{x'x'} = K_{xx}^{x'x'} = 1/4 \quad (14)$$

$$A_{xx} = A_{zz} = K_{xx}^{y'y'} = K_{zz}^{y'y'} = - 1/2 \quad (15)$$

$$P^{x'x'} = P^{z'z'} = K_{yy}^{x'x'} = K_{yy}^{z'z'} = - 1/2 \quad (16)$$

The quantities P,A and K denote the polarization of the scattered deuterons, the analyzing power and the polarization transfer coefficients respectively. With these conditions a straighforward experimental identification of a point $A_y = \pm 1$ or $A_{yy} = 1$ is possible. Care should be taken to verify each condition in several ways, choosing the observables by an inspection of the general formulae and taking into account the relations between observables required by other symmetries[3].

## References

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