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POINTS OF MAXIMUM POLARIZATION EFFICIENCY IN He(d,d) 4He

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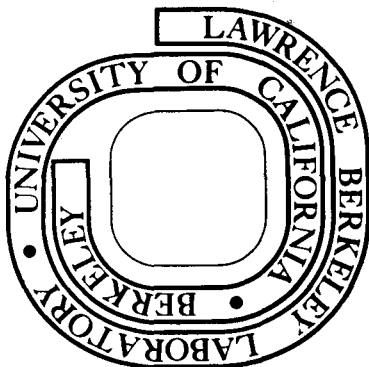
F. Seiler, H. E. Conzett, F. N. Rad, and R. Roy

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

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Several points (E_i, θ_i) of maximum possible analyzing power have recently been identified in $d-{}^4\text{He}$ 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 energy¹⁾. An experimental indication that extreme values of the analyzing power A_y may occur comes from measurements near $E_d = 28$ MeV and $\theta_{\text{cm}} \approx 154^\circ$, where $A_y \approx A_{yy} \approx 1$ 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, θ_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 conditions¹⁾. In an alternate approach⁵⁾ these conditions are introduced into the formulae for the observables³⁾ and can then be checked experimentally. The requirement $B = 0$ for $A_{yy} = 1$ yields

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

$$A_{xx} = P^{x'x'} = K_{yy}^{x'x'} = K_{xx}^{y'y'} \quad (2)$$

$$A_{zz} = P^{z'z'} = K_{zz}^{y'y'} = K_{yy}^{z'z'} \quad (3)$$

$$K_x^{x'} = K_z^{x'} = K_{xy}^{x'} = K_{yz}^{x'} = 0 \quad (4)$$

$$K_x^{z'} = K_z^{z'} = K_{xy}^{z'} = K_{yz}^{z'} = 0 \quad (5)$$

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

$$K_x^{y'z'} = K_z^{y'z'} = K_{xy}^{y'z'} = K_{yz}^{y'z'} = 0. \quad (7)$$

Eqs. (4) to (7) are particularly important, since a value of zero at (E_i, θ_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 σ_0 at (E_i, θ_i) . Thus all 51 polarization observables are numerically determined, and in addition to eqs. (4) to (7) the following conditions hold

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

$$A_{YY} = P^{Y'Y'} = K_{Y'Y'} = K_{YY}^{Y'Y'} = 1 \quad (9)$$

$$A_{XZ} = P^{X'Z'} = K_{XZ}^{X'Z'} = 0 \quad (10)$$

$$K_{XZ}^{Y'Y'} = K_{XZ}^{X'X'} = K_{XZ}^{Y'Y'} = K_{XZ}^{Z'Z'} = 0 \quad (11)$$

$$K_{Y'Y'}^{X'Z'} = K_{XX}^{X'Z'} = K_{YY}^{X'Z'} = K_{ZZ}^{X'Z'} = 0 \quad (12)$$

$$K_{Y'Y'}^{Z'Z'} = K_{ZZ}^{Y'Y'} = K_{Y'Y'}^{X'X'} = K_{XX}^{Y'Y'} = \mp 1/2 \quad (13)$$

$$K_{ZZ}^{Z'Z'} = K_{XX}^{Z'Z'} = K_{ZZ}^{X'X'} = K_{XX}^{X'X'} = 1/4 \quad (14)$$

$$A_{XX} = A_{ZZ} = K_{XX}^{Y'Y'} = K_{ZZ}^{Y'Y'} = - 1/2 \quad (15)$$

$$P^{X'X'} = P^{Z'Z'} = K_{YY}^{X'X'} = K_{YY}^{Z'Z'} = - 1/2 \quad (16)$$

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 straightforward 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 symmetries³⁾.

References

- * Work performed under the auspices of the U.S. Energy Research Development Administration
- + On leave of absence from the University of Basel, Switzerland
- ‡ National Research Council of Canada, Postdoctoral fellow
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