Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 886-887

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A Maximum Tensor Analyzing Power $A_{yy} = 1$ in d-α Elastic Scattering near 35 MeV

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At special energies and angles an analyzing power of a nuclear reaction or scattering may reach its theoretical maximum value. Such points give a deep insight into the structure of the corresponding compound nucleus. Moreover, they are urgently needed as absolute polarization standards to calibrate polarized beams.

A point of a maximum analyzing power is connected with certain relations between the elements of the M-matrix of the corresponding reaction or scattering. In particular in d-α elastic scattering a value of $A_{yy} = 1$ occurs if the sum of the spin-flip amplitude M_{1-1} and the non-flip amplitude M_{11} vanishes[1]. A phase-shift analysis of d-α scattering[2] for energies up to 43 MeV shows that one can expect such a point in the region of 35 MeV and $\theta_{cm} = 150°$. To find out the exact location, one has to map experimentally the E, θ_{cm} region. Interpolation of this measured data will then reveal the exact E and θ_{cm} values at which the maximum of A_{yy} occurs.

We have carried out such an investigation with the polarized deuteron beam from the SIN injector cyclotron, which normally has a perpendicular beam axis, so that with two detectors left and right in the horizontal plane A_{yy} can be determined. At 8 energies from 31.8 MeV to 39.0 MeV we have measured the angular distribution of A_{yy} for the recoil α-particles of the d-α elastic scattering in the lab angular range from 10° to 20°, corresponding to a cm angular range from 140° to 160°. The beam polarization was measured continuously with a polarimeter at 0°, using the $^3He(d,p)^4He$ reaction. These angular distributions have been fitted with polynomials, giving for each angular distribution the interpolated maximum value and the angle where the maximum occurs. Finally all the interpolated maxima have been fitted to find the exact energy and angle of the absolute maximum value. Since the phase-shift analysis demands a value of +1 for this maximum, we had to multiply the experimental analyzing powers by a normalization factor of 1.025.

Fig. 1 shows the normalized measured angular distributions with fits and the fit of the interpolated maxima. The value $A_{yy} = 1$ occurs at $E_d = 35.5$ MeV and $\theta_{cm} = 151.5$. This maximum is not very sensitive to the energy: over an energy range of ± 2.5 MeV the A_{yy} value deviates by not more than 1%. Also the angular sensitivity is not critical: within a ± 3.5° range the A_{yy} value is 99% of the maximum.

For deuteron energies above about 20 MeV this maximum is the first point found with $A_{yy} = 1$ and it can be used for the absolute calibration of deuteron tensor polarization. In the phase-shift analysis[2] two broad resonances are observed in the energy region of this A_{yy} maximum, corresponding to a 3^- and a 4^+ level in ^6Li with excitation energies of 24 and 23.5 MeV respectively.

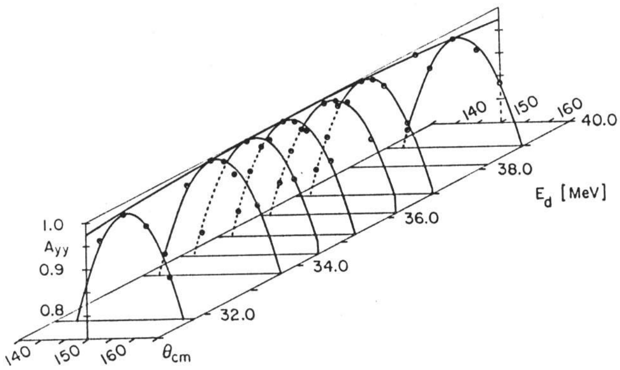

Fig. 1. Angular distributions of the analyzing power A_{yy} for energies from 31.8 MeV to 39.0 MeV and fits of this data. The fit of the interpolated maxima is also given.

References

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