

ELASTIC SCATTERING OF POLARIZED DEUTERONS
FROM ^4He BETWEEN 18 AND 22 MeV

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Angular distributions of polarized deuterons scattered from ^4He have been measured for 17.7, 19.7 and 21.4 MeV incident energy. Vector- and tensor-polarization parameters are presented.

Elastic scattering of deuterons from ^4He in the vicinity of the $^3\text{He} + ^3\text{H}$ threshold has recently been the subject of several experimental investigations; the data disagree slightly but show an important energy dependence of the differential cross section [1-4]. Phase shift analysis of low energy data [5, 6] appears to be a powerful tool in understanding the level scheme of ^6Li , to which theoretical interest is attached, due to the simplicity of its shell model [7] and cluster model [8] descriptions. Furthermore, polarization parameters can be computed from the phase shifts allowing deuteron-alpha scattering to be used either as an analyzer or as a generator of polarized deuterons. Towards higher energies, extraction of phase shifts from the cross section data becomes quickly ambiguous: absorption is so important that the sensitivity of the scattering amplitudes to the real parts of the phase shifts is weakened; on the other hand, various sets of phase shifts can generate the same cross section and a knowledge of the polarization parameters is needed to discriminate between them [9, 10]. The purpose of this note is to report on a measurement of these parameters at 17.7, 19.7 and 21.4 MeV incident deuteron energy.

The 22 MeV polarized deuteron beam (2×10^8 particles per second; energy spread 300 keV) of the Saclay fixed frequency cyclotron is brought to a focus in a helium target, the pressure of which (2 kg/cm^2) is kept constant by means of a mercury manostat. A carbon polarimeter located downstream allows continuous monitoring of the beam polarization. Two aluminium absorbers, 0.2 mm thick, are used in such a way that the

energy remains the same in the polarimeter but can take, in the center of the gas target, the values 17.7, 19.7 and 21.4 MeV. Two counter telescopes (2.2° angular resolution) can be rotated around the gas target on each side of the beam. Each counter is made of a pair of solid state silicon detectors (one surface barrier, one lithium drifted) in order to discriminate between the scattered deuterons and the breakup protons. In a few instances (forward angles), the α recoils can be detected. After amplification through standard electronic circuitry, the pulses are analysed in a 4000-channel kicksorter. Absorbers located in front of the polarimeter counters (lithium drifted silicon detectors at 50° lab angle) allow selection of the proton group in the $^{12}\text{C}(d, p)^{13}\text{C}$ reaction, the pulses being recorded on scalars after amplification.

The incident deuteron beam is polarized before acceleration [11], the sign of its tensor- and vector-components being reversed every 0.2 second. This allows, by detecting the scattered particles in both horizontal and vertical planes, to measure the following quantities

$$P = \frac{1}{\sqrt{3}} \frac{t_1^1}{t_1^0},$$

$$Q = \frac{1}{\sqrt{2}} \left(\frac{1}{2} t_0^2 + \sqrt{\frac{3}{2}} t_2^2 \right),$$

$$R = \frac{1}{\sqrt{2}} \left(\frac{1}{2} t_0^2 - \sqrt{\frac{3}{2}} t_2^2 \right),$$

the t_μ^λ being the helicity components on the irreducible tensor operators [12]

$$T_\mu^\lambda = \frac{1}{3} \sum_{mm'} (-1)^{1-m'} \langle 11m - m' | \lambda \mu \rangle | 1m \rangle \langle 1m' |$$

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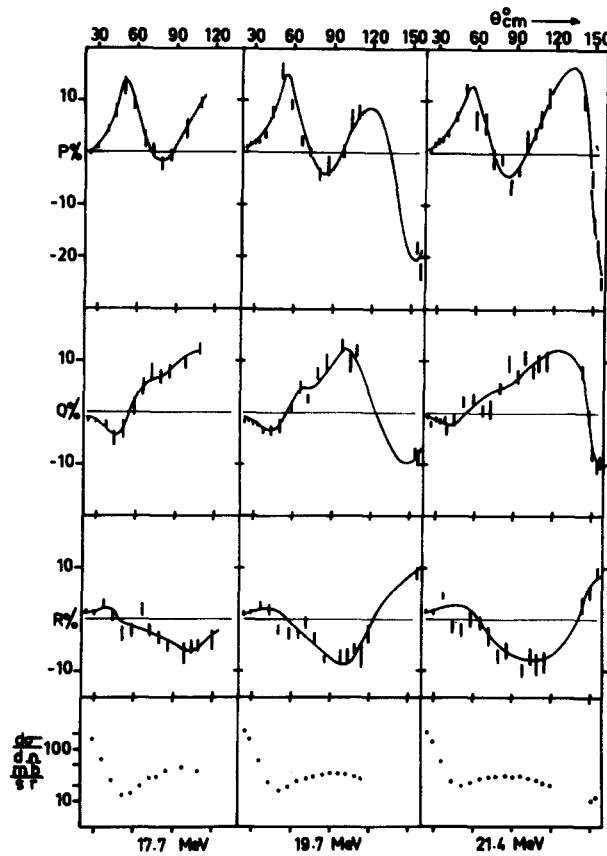


Fig. 1. Asymmetry parameters P , Q and R as defined in the text for 17.7, 19.7 and 21.4 MeV incident energy. The solid curves are the results of a preliminary phase shift analysis.

of the density matrix

$$\rho = \frac{1}{3} \sum_{\lambda \mu} (-1)^\mu t_\mu^\lambda T_{-\mu}^\lambda$$

which would describe the scattered particles if the incident beam were unpolarized. They are related to Senhouse's $\langle T_\mu^\lambda \rangle$ [9] through the rotation matrices

$$\langle T_\mu^\lambda \rangle = \sum_{\mu'} R_{\mu\mu'}^* (0, \theta, 0) t_\mu^\lambda,$$

where θ is the center-of-mass scattering angle.

The results are presented in fig. 1. Error bars include statistical and systematic uncertainties. Absolute normalization is achieved by comparing the polarimeter data with previous results of Beurtey [11]; an uncertainty of 6% is attached to this normalization.

No important energy dependence, as could be expected from ref. 4, is found. The asymmetries are smaller than at lower energies: helium does

not appear as very efficient analyzer of deuterons in the 20 MeV region.

A preliminary phase shift analysis of the data (including cross section measurements [2, 3, 4]) shows that F and G waves contribute to the scattering. The P waves remain unsplit and the coupling parameters are small. High absorption coefficients are needed to fit the large forward differential cross sections, generating reaction cross sections of the order of 3 to 4 barn.

A more detailed account of this work will be published later.

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ON THE ENERGIES OF THE OCTUPOLE STATES OF EVEN-EVEN NUCLEI IN THE ENERGY REGION $228 \leq A \leq 254$

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More accurate calculations of the energies of octupole states of even nuclei in the region $228 \leq A \leq 254$ are given.

The nuclear model with pairing and octupole-octupole interaction was used in ref. 1 to calculate the energies of the octupole states of even-even deformed nuclei and their structure. The results of the calculations are in satisfactory agreement with the corresponding experimental data including those obtained after performing calculations, e.g. ref. 2. The only free parameter - the octupole-octupole interaction constant $\kappa^{(3)}$ - was chosen so as to obtain the best agreement between the calculated and experimental energies of the $K^\pi = 0^-$ states in the region $228 \leq A \leq 254$.

As is known, the $K^\pi = 0^-$ states in the Th, U and Pu isotopes are collective and their energies are strongly lowered with respect to the corresponding poles. The $K^\pi = 1^-$ and 2^- states are weakly collective and their energies lowered by about 100 - 300 keV with respect to the poles.

According to the method of approximate second quantization, the accuracy of calculations becomes essentially worse for states whose energies are very strongly lowered with respect to the poles (see e.g. ref. 3). Therefore it is necessary to determine the value of $\kappa^{(3)}$ from the $K^\pi = 1^-$ and 2^- states and thereby somewhat improve the results of calculations given in ref. 1. In the present note one gives more accurate calculations of the energies of the octupole states of even-even nuclei in the region $228 \leq A \leq 254$ which may turn out to be useful in performing

further experimental investigations.

The energies and the structure of the $K^\pi = 1^-$ and 2^- states are calculated for $\kappa^{(3)} = 0.00045 \hbar\omega_0$ while for the $K^\pi = 0^-$ states the value of $\kappa^{(3)}$ is taken by 10% smaller in order to improve effectively the accuracy of the method. The two-three first poles are equal to the energies of the two-quasi-particle states given in ref. 4. The value of $\kappa^{(3)}$ is decreased as compared to the calculations in ref. 1; because of the increase of the number of the average field levels the calculations are made according the scheme II given in ref. 5. The results of calculations are tabulated. From table 1 it is seen that the calculated energies agree sufficiently well with experimental data. By making $\kappa^{(3)}$ more accurate one has obtained some improvement of agreement with experiment as compared with the results of paper 1.

We discuss the peculiarities of the octupole states in some nuclei. The $I^\pi K = 1^-1$ state in ^{234}U possesses an energy of 1438 keV [6], the calculated energy of the first $I^\pi K = 1^-1$ state is 940 keV and of the second one is 1450 keV. It may be therefore assumed that the experimentally observed $I^\pi K = 1^-1$ state of energy 1438 keV is the second $I^\pi K = 1^-1$ state.

An interesting situation takes place in ^{246}Cm . In ref. 2 three octupole states are observed, two with $I^\pi K = 1^-1$ and energies 1080 and 1351 keV and one with $I^\pi K = 2^-2$ and energy 842 keV. According