ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Bologna

INFN/BE-79/6
8 Novembre 1979

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Servizio Documentazione
dei Laboratori Nazionali di Frascati

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CROSS SECTIONS MEASUREMENT OF D(α, α)D ELASTIC SCATTERING.

1. - INTRODUCTION.

In the present work we report a sistematic measurement of the cross sections of the elastic scattering:

$$\alpha + d \longrightarrow \alpha + d \tag{1}$$

at several energies and kinematical configurations.

The study of this process leads to direct information on the parameters of the excited states of ^{6}Li.

The elastic scattering cross sections were investigated in the past by several authors[1-3]. The most complete works on this subject are those of Senhouse and Tombrello[1] and of the Zürich group[2]. The first group measured angular distributions in a wide range of energies whereas the second one have performed measurements both of the cross sections and of the vector and tensor analyzing power.

Some discrepancies, nevertheless, are present between the results of the two groups in the phase-shift analysis. In particular quite different results are obtained for the mixing parameter of s and d partial waves and for the existence of three p-levels[4].

From a more general point of view the results of the cross sections measurement in the elastic scattering (1) could be exploited in principle for a microscopic treatment of a 6-nucleons system. However for practical purposes the α-d scattering, in fact, can be treated approximately as a three-body system where the α-particle is considered a structureless object and the deuteron as a bound p-n system[5, 6].

In such a way a theoretical treatment of the α-d system can be performed in the framework of the Faddeev' equations.

As known, this theoretical approach has to account not only for the elastic scattering, but also for the break-up reaction:

$$\alpha + d \longrightarrow \alpha + p + n \tag{2}$$

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as well as for other reactions like

$$\alpha + d \rightarrow \alpha + d + \gamma \ , \tag{3}$$

and

$$\alpha + d \rightarrow {}^6Li + \gamma \ . \tag{4}$$

A better understanding of the microscopic reaction mechanism can be obtained by comparing the experimental behaviour of all the previous reactions with the prediction of specific models.

From this point of view, therefore, we look at the elastic scattering as a first step of a program of experiments involving also reactions (2), (3) and (4).

For these reasons and for the discrepancies existing in the results of previous works, we have measured detailed angular distributions in the elastic scattering at 39 different energies.

2. - EXPERIMENTAL.

The experiment was performed at the Van de Graaf generator of the Laboratori Nazionali di Legnaro with the He^{++} beam in the energy range between 6 and 14 MeV.

Since we required low statistical errors and a good angular definition ($\Delta\vartheta = 0.5^o$), solid polystyrene deuterated targets were used. These targets, in fact, have a relatively large number of deuterium centers and a very small thickness, which provide high counting rates, good angular resolution and a negligible energy loss[7].

In order to reject spurious events coming from reactions in the target backing and from impurities in the beam, we have recorded the recoiling deuterons in coincidence with the scattered α-particles.

As shown in Fig. 1, the deuterons were recorded at four different angles at the same time by four surface barrier detectors in coincidence with the same large area α-particles detector[8].

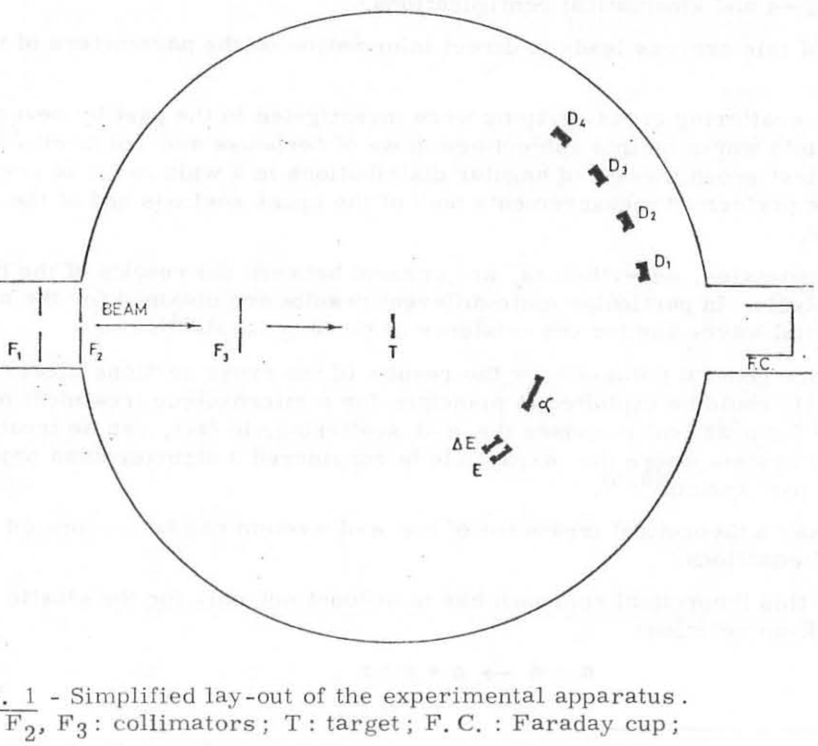

FIG. 1 - Simplified lay-out of the experimental apparatus. F_1, F_2, F_3 : collimators ; T : target ; F. C. : Faraday cup ; D_1, D_2, D_3, D_4 : deuterons detectors ; α : alpha particle detector ; ΔE, E: monitor telescope.

In such a way we have measured angular distributions from $\theta_{Lab} = 7^o$ to 69^o in steps of 2^o.

The content of deuterium in the target during the measurements at the same energy, was continuously monitored by a $\Delta E - E$ system recording deuterons emitted at a fixed angle of 50^o.

3. - RESULTS.

The experimental results are plotted in Figs. 2.

In order to match the data at different energies, excitation functions were performed at four angles (see Fig. 3).

The loss of deuterium in the target was taken into account alternating the measurement at the energy of interest and at an incident reference energy $E_\alpha = 9.847$ MeV.

The data at this energy were furthermore used to obtain absolute values of cross-sections by normalization to the values obtained in experiments with gaseous targets(1).

A comparison between the present results and those of ref. (1) are shown in Fig. 4, were the cross-sections obtained from a phase-shift theoretical prediction(5) are also reported.

ACKNOWLEDGEMENTS.

The authors are indebted to Mrs. G. Busacchi and A. Grilli for their skillful technical assistence. The authors would also thank the technical equipe of the Laboratori Nazionali di Legnaro for the hospitality at the Laboratory.

REFERENCES.

(1) - L. S. Senhouse and T. Tombrello, Nuclear Phys. 57, 624 (1964).
(2) - R. A. Hardekopf, W. Grüebler, B. Jenny, V. König, R. Risler, M. R. Bürgi and J. Nurzynski, Nuclear Phys. A287, 237 (1977) and references quoted therein.
(3) - G. G. Ohlsen and P. G. Young, Phys. Rev. B136, 1632 (1964).
(4) - P. A. Schmelzbach, W. Grüebler, V. König and P. Marmier, Nuclear Phys. A184, 193 (1972).
(5) - See e. g. Y. Koike, Progr. Theor. Phys. 59, 87 (1978).
(6) - B. Charnomordic, C. Fayard and G. M. Lamot, Phys. Rev. C15, 864 (1977); C. Fayard, private communication.
(7) - M. Bruno, M. D'Agostino and M. Lombardi, Lett. Nuovo Cimento 22, 556 (1978).
(8) - M. Lombardi, C. Baiocchi, I. Carraro, P. Schiavon and G. Prete, Report INFN/TC-78/5 (1978).

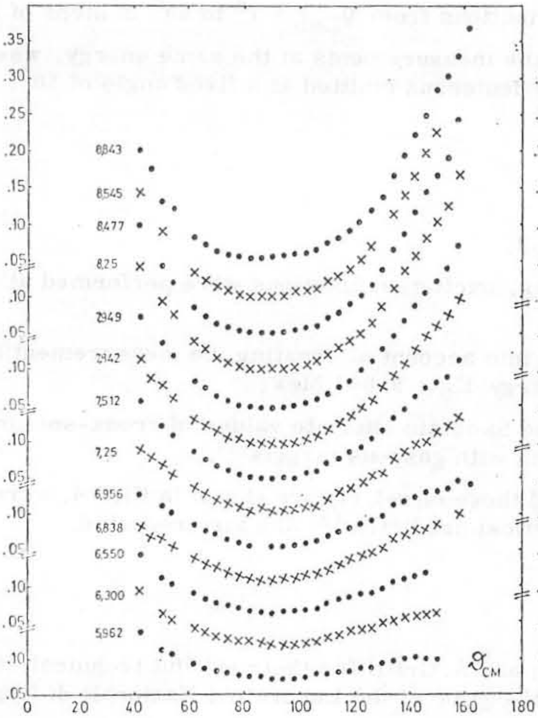

FIG. 2a - Angular distributions in the energy range : 5.962 - 8.843 MeV; Right scale is for (●) whereas left scale is for (x).

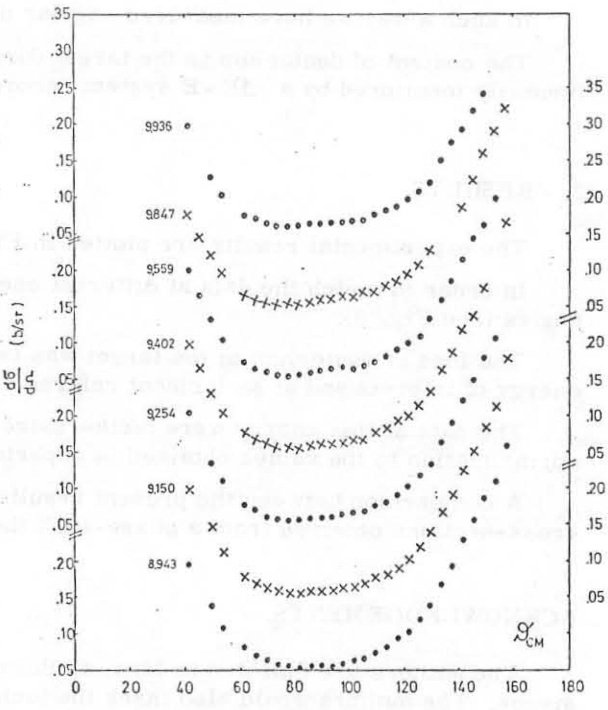

FIG. 2b - Angular distributions in the energy range : 8.943 - 9.936 MeV ; Right scale is for (●) whereas left scale is for (x).

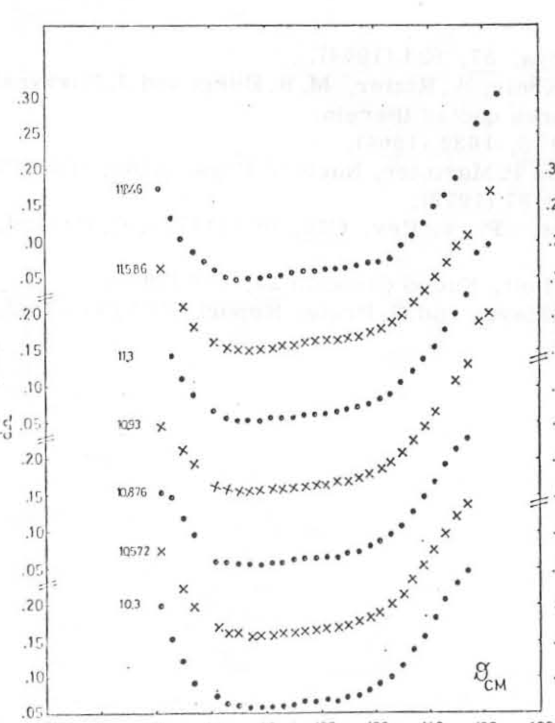

FIG. 2c - Angular distributions in the energy range : 10.3 - 11.846 MeV ; Right scale is for (●) whereas left scale is for (x).

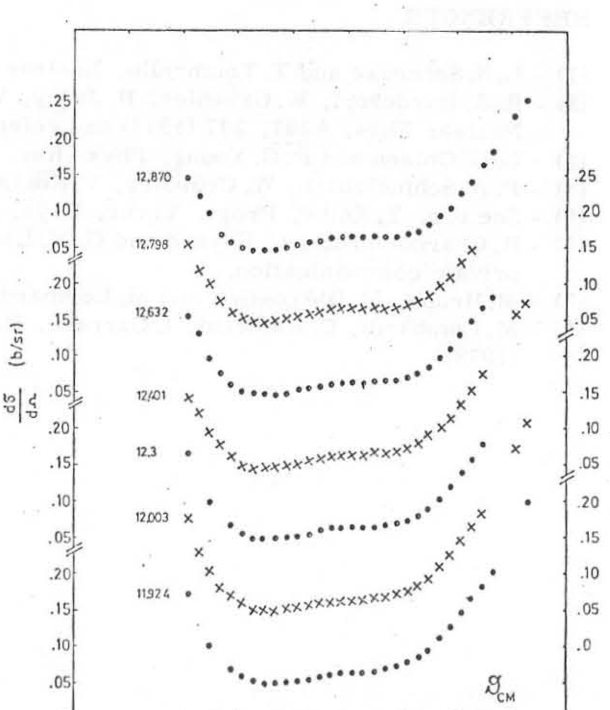

FIG. 2d - Angular distributions in the energy range : 11.924 - 12.87 MeV ; Right scale is for (●) whereas left scale is for (x).

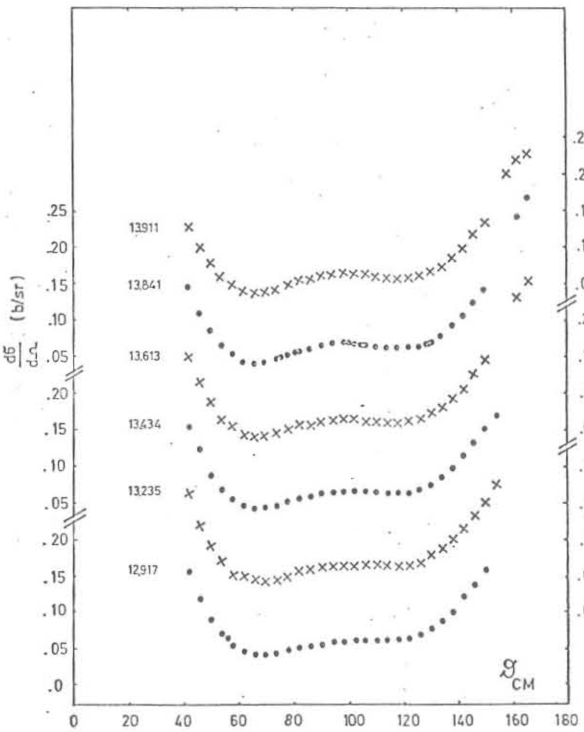

FIG. 2e - Angular distributions in the energy range : 12. 917 - 13. 911 MeV; Right scale is for (•) whereas left scale is for (x).

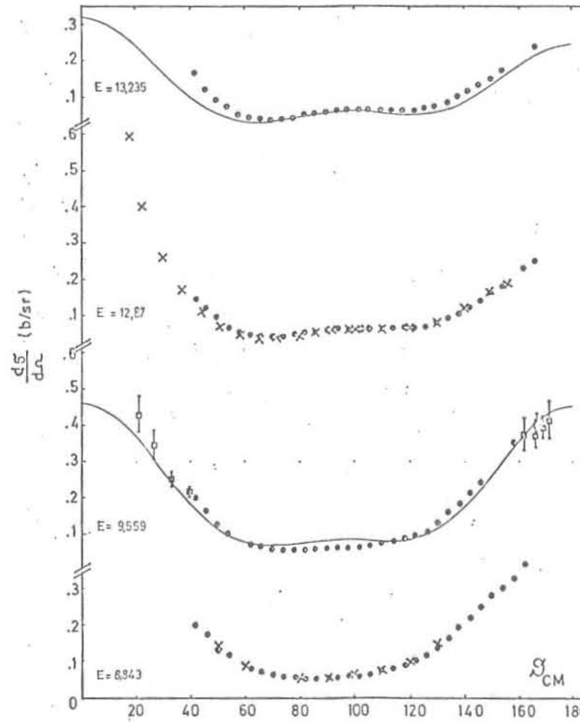

FIG. 4 - Comparison of angular distributions of present work (•) : a) and c) with those of ref. (1) (x) ; b) and d) with theoretical predictions of ref. (5) (continuous line). Note that the forward and backward scattering angles (◘) are measured not in coincidence and have a larger error than the other points.

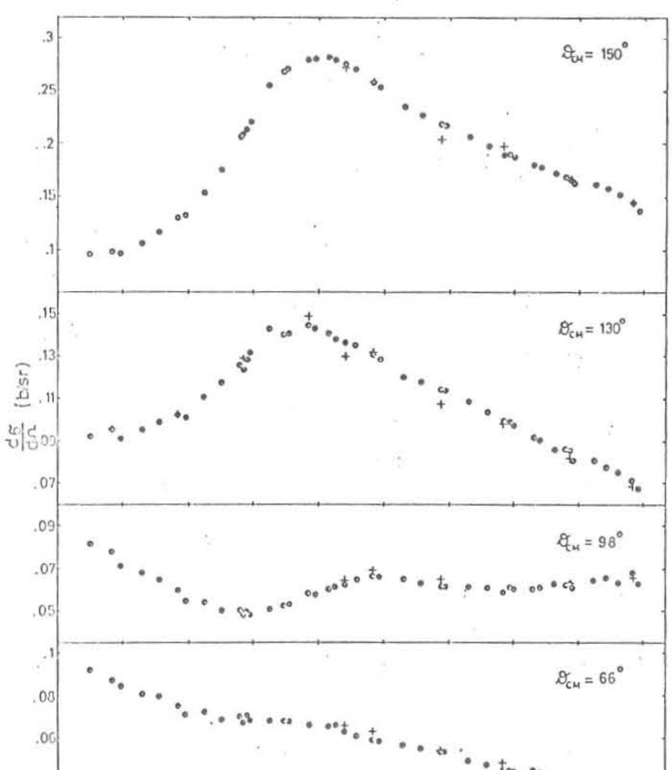

FIG. 3 - Excitation function of D(α, α)D. a) ϑ_{CM} = 150°; b) ϑ_{CM} = 120°; c) ϑ_{CM} = 98° and d) ϑ_{CM} = 66°.

(•) present work, (x) ref. (1).