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PREFACE

CONTENTS

I. Institut de Physique, Université de Neuchâtel

(Dir.: Prof. Jean Rossel)

1. A measurement of differential cross section for the D(n,n)D reaction at 2.45 and 3.27 MeV

D. Bovet, P. Chatelain, Y. Onel and J. Weber

In the progress report 1976 we have reported that we have started the measurement of the differential cross section for the nd elastic scattering by using the method of recoil energy spectrum.

Since then we have performed the following measurements:

1 - np → np, NE213-H, 2x2 cm (scatterer) E_n = 2.45 MeV
{to test the experimental set-up and the method of data analysis}
2 - nd → nd, NE213-D, 3x3 cm, E_n = 2.45 MeV
3 - nd → nd, NE213-D, 2x2 cm, E_n = 2.45 MeV
4 - nd → nd, NE213-D, 1x1 cm, E_n = 2.45 MeV
5 - nd → nd, NE213-D, 1x1 cm, E_n = 3.27 MeV

The experimental method for these measurements has been described in the progress report 1976. We would like to mention that the (n,γ) discriminator which has also been described in the report 1976 was included in the electronics with great success.

A Monte Carlo program has been designed to correct the effects of multiple scattering on the observed spectra.

By using the measurements 2 - 4 we could apply corrections to the data for the edge-effects.

Preliminary results of this experiment show that the differential cross section at 2.45 MeV is more peaked (about 25 %) at the large angles than the previous measurement (BNL-400). This would imply that terms with ℓ_{max} higher than 2 have to be included in the phase shift analysis; however this preliminary conclusion needs further investigation.

At present we are continuing with the measurements of depolarization parameter $D(\theta)$ for the $D(\vec{n},\vec{n})D$ reaction at 2.45 MeV.

2. Three body reactions

F. Foroughi, E. Bovet, C. Nussbaum and J. Rossel

During the past year two experiments have been performed on the α-α final state interaction and on the deuton break-up by an α-particle.

a) Final state interaction

The aim of this experiment was to compare the α-α and p-p FSI at a low relative energy. In the p-p case, the coherence effect {1} allows the reproduction of the observed shape of the spectra on the basis of the Jost function. The correct interpretation of the results however remains difficult as long as no method exists to solve the Faddeev equations with a Coulomb potential. In this connection we found it interesting to study the α-α FSI for comparison with the p-p FSI. From calculations {2} based on phenomenological potentials and on the method of resonating groups it appears that the results should be similar to the p-p case in the potential part (without the 0^+ ^{8}Be resonance which cannot be reproduced).

We have consequently studied the ^{6}Li(α,αd)α reaction for two configurations: $\theta_\alpha = -25^\circ$, $\theta_d = 85.1^\circ$ at $E_\alpha = 42$ MeV and $\theta_\alpha = -15^\circ$, $\theta_d = 117.3^\circ$ at $E_\alpha = 41.75$ MeV. The target was made of self supporting ^{6}Li with an isotopic purity of 99.6 %.

The results are shown on fig. 1 and 2. It may be seen that no signal appears between the 0^+ and 2^+ peaks, in the interesting region. From this result one concludes that the p-p and α-α FSI are not similar (the last one is dominated by the 0^+ state of ^8Be) so that, despite the fact that the observed spectral shape may be explained, the fundamental FSI mechanism is not yet understood.

The 0^+ resonance on the ground state of ^8Be has a width of 7 eV {3}. The width of the observed peaks is compatible with this value, taking into account the various broadening effects (electronics, beam resolution, etc.); this appears clearly on fig. 3. This result is probably one of the most spectacular "lense effects" in reactions with 3 particles in the final state.

b) D(α,αp)n reaction

Four different configurations have been examined (see fig. 4) with an energy of 42 MeV for the incident α-particle. The target was deuterizated polyethilene of 99 % isotopic purity. We have compared the results with two models: The "impulse approximation" and the Cahill model {4}. This last one had to be adapted for the inclusion of the Coulomb potential. Comparison with the experiment shows that these models are not adequate. At this energy the differential cross section of the reaction D(α,α)D is only known {5} from 17^o in the CM system. This makes the cut-off difficult which is necessary for the integration on the elastic amplitude. (A cut-off angle must be introduced to avoid the divergence of the Coulomb amplitude at 0^o).

We feel that our results clearly show the difficulties of approximation methods in N-body processes when the Coulomb contribution to the scattering cannot be neglected.

We continue these studies on the α-n-p system taking advantage of the solution of the Faddeev equations in configuration space {6}.

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{3} J. Benn, E. B. Dally, H. H. Muller, R. E. Pixley, W. H. Staub and H. Winkler; Phys. Lett. 20, 43 (1966)

{4} R. T. Cahill; Phys. Lett. 49B, 150 (1975), F. Foroughi and E. Bovet; Helv. Phys. Acta 48, 577 (1975)

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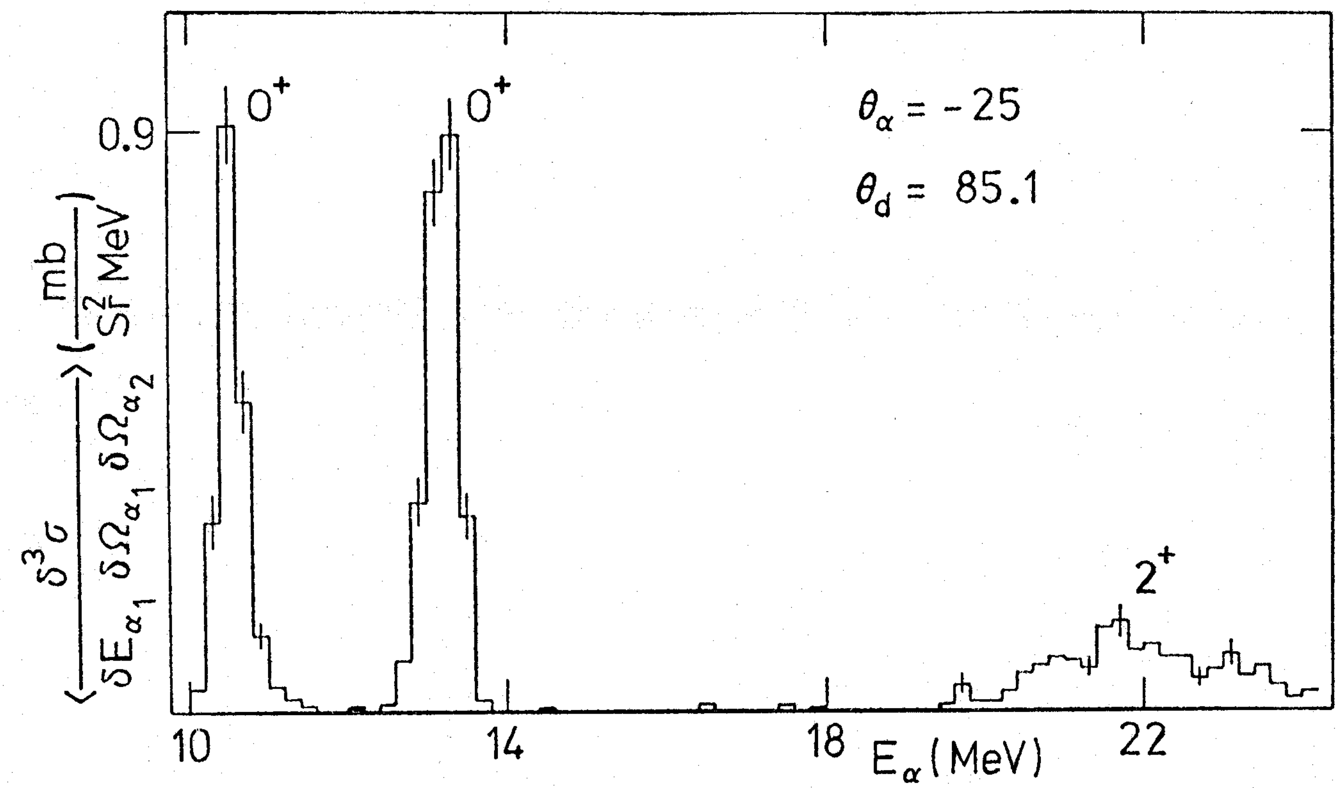


Fig. 1: Measured $^6Li(\alpha,\alpha d)\alpha$ reaction.
$\theta_\alpha = -25^o$, $\theta_d = 85.1^o$, $E_\alpha = 42$ MeV.

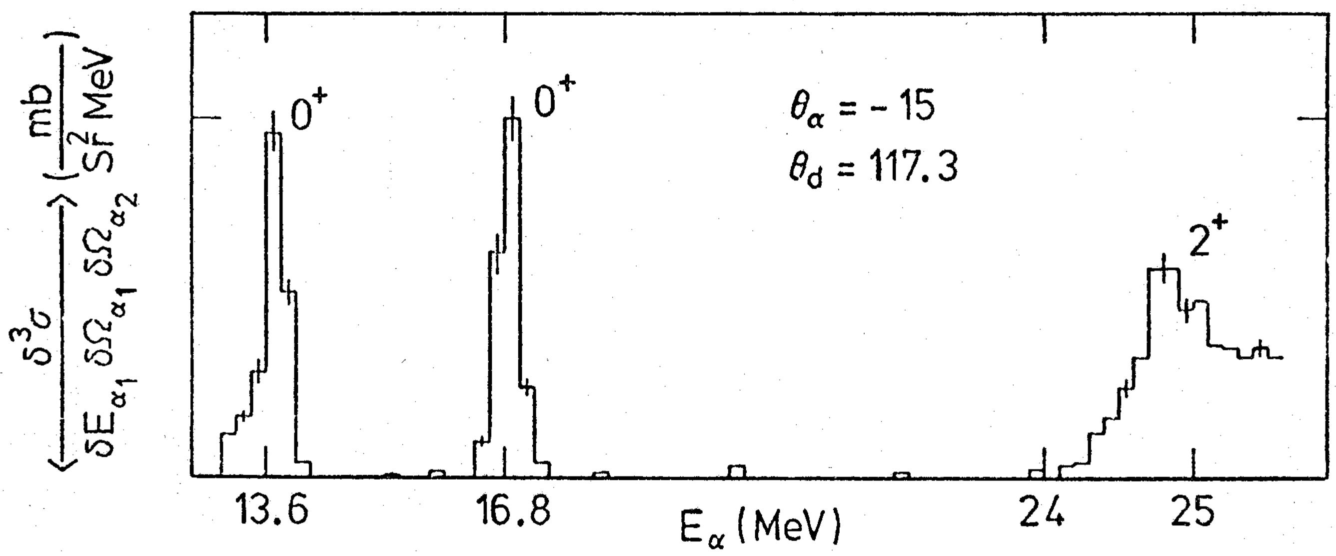


Fig. 2: Measured $^6Li(\alpha,\alpha d)\alpha$ reaction.
$\theta_\alpha = -15^o$, $\theta_d = 117.3^o$, $E_\alpha = 41.75$ MeV.

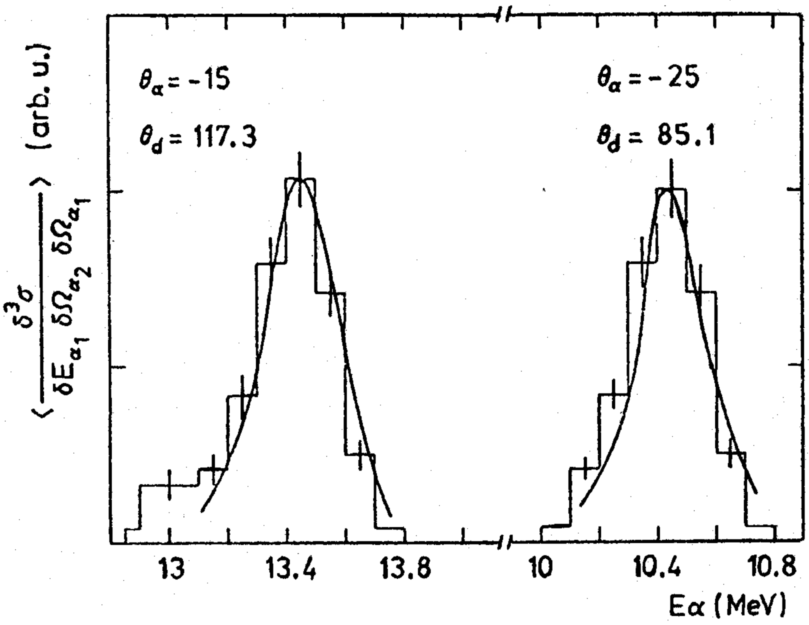


Fig. 3: ^{6}Li(α,αd)α reaction.
0^+ resonance on the ground state.

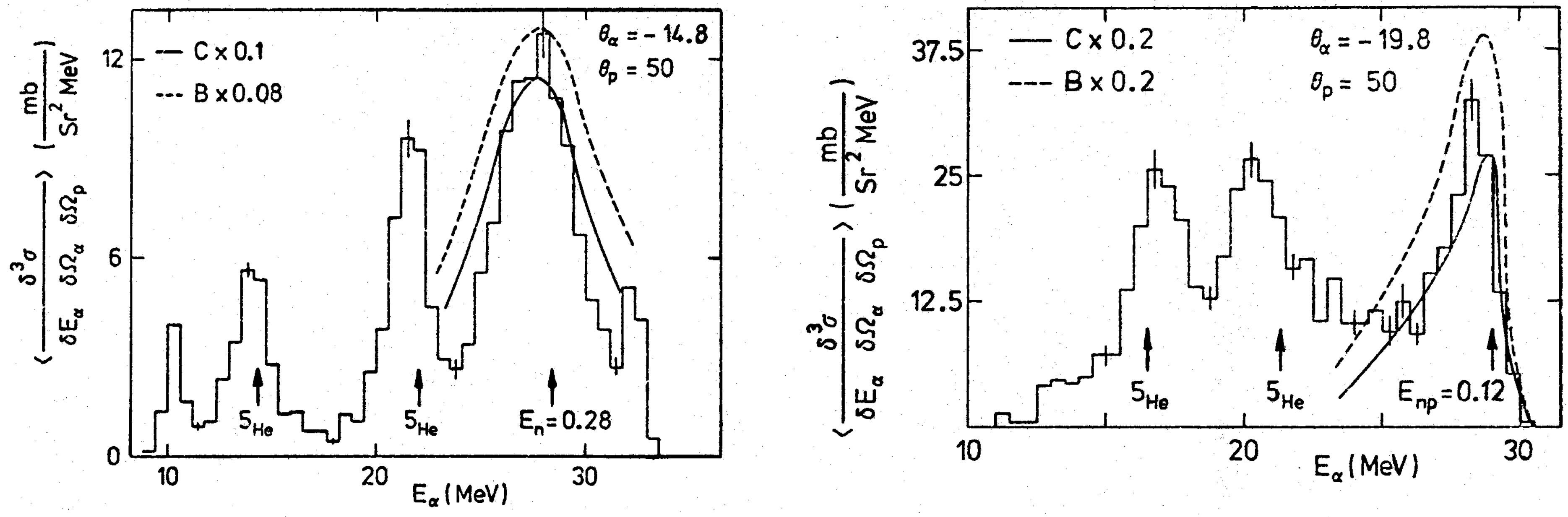
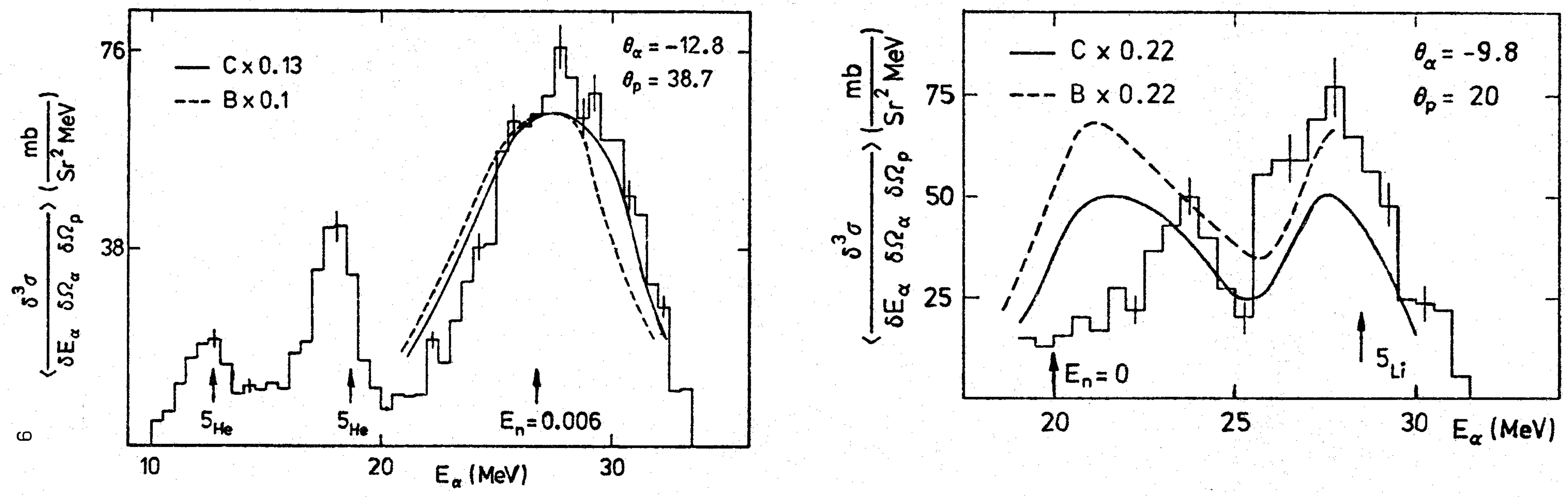


Fig. 4: D(α,αp)n reaction. Incident α-energy E_{α} = 42 MeV.



II. Eidg. Institut für Reaktorforschung, Würenlingen and Anorg. chem. Institut, Universität Bern, Bern

1. Independent yields of ^{96}Nb and ^{98g}Nb in the thermal neutron fission of ^{233}U, ^{235}U and ^{239}Pu

T. Kaiser and H. R. von Gunten

Nb was isolated and purified from fission products by adsorption and desorption on fibre glass filters. ^{96}Nb and ^{98}Nb were measured relative to ^{97}Nb using GeLi detectors. The independent and fractional independent yields for ^{96}Nb and ^{98g}Nb are shown in tables 1 and 2, respectively.

2. Mass distribution in the 0.3 eV neutron resonance of ^{239}Pu

T. Kaiser and H. R. von Gunten

Yields were measured of ^{91}Sr, ^{111}Ag, ^{112}Ag, ^{113}Ag, ^{115}Cd, ^{117}Cd and ^{117m}Cd in the 0.3 eV neutron resonance in the fission of ^{239}Pu. The irradiations were performed in Gd and Cd filters of proper thickness. The fission products of interest were isolated using radiochemical techniques. Gamma-ray-spectroscopy was used for the measurements of the samples. The results are shown in table 3. The peak-to-valley ratio (^{99}Mo/^{115}Cd) increases in this resonance by 1.54 $\pm$ 0.35 compared to that in thermal neutron-induced fission.

3. Independent and fractional cumulative yields in the thermal neutron-induced fission of ^{249}Cf

H. Gäggeler and H. R. von Gunten

The independent yields of ^{96}Nb, ^{98g}Nb, ^{130g}I and ^{136}Cs and the fractional cumulative yields of ^{135}I were measured in the thermal neutron-induced fission of ^{249}Cf. Radiochemical techniques were used for these determinations. The results are shown in table 4. Included in the table are Zp-values (most probable charge) corresponding to the fractional independent yields if a Gaussian charge distribution with $\sigma = 0.56 \pm 0.06$ is assumed. The values for Z_{UCD} (unchanged charge distribution) are obtained with the same ratio of protons and neutrons in the fissioning nucleus and in the resulting fission products. ΔZ is the difference $Zp-Z_{UCD}$.

Table 1: Independent yields of ^{96}Nb in thermal neutron-induced fission of ^{233}U, ^{235}U and ^{239}Pu

Target	Ind. yield (%)	Fract. ind. yield	Yield of isobar 96 {1} (%)	Yield of isobar 97 {1} (%)
^{233}U	$(5.3 \pm 0.3) \cdot 10^{-3}$	$(9.3 \pm 0.4) \cdot 10^{-4}$	5.67 ± 0.06	5.45 ± 0.05
^{235}U	$(5.2 \pm 0.2) \cdot 10^{-4}$	$(8.3 \pm 0.4) \cdot 10^{-5}$	6.25 ± 0.04	5.96 ± 0.08
^{239}Pu	$(3.6 \pm 0.2) \cdot 10^{-3}$	$(7.1 \pm 0.3) \cdot 10^{-4}$	5.09 ± 0.10	5.62 ± 0.22

{1} Meek and Rider, Compilation (1974)

Table 2: Fission yield of ^{98g}Nb

Target	Yield (%) This work	Fract. yield This work {1}	Yield (%) {2}	Fract. yield {3}	Fract. ind. yield of both isomers ^{98}Nb (calculated) {4}
U-233	0.14 ± 0.02	0.027 ± 0.004	0.20		0.045
U-235	0.047 ± 0.002	0.0081 ± 0.0004	0.064	0.0081 ± 0.0004	0.01
Pu-239	0.17 ± 0.02	0.021 ± 0.004	0.20		0.047

{1} Upper limit for the yield of ^{98g}Nb

{2} Katcoff, Nucleonics 18, 201 (1960)

{3} Blachot et al. Symp. Phys. and Chem. of Fission, Vienna 1969

{4} Wolfsberg, LA-5553-MS (1974)

Table 3: Chain yields in the 0.3 eV - neutron resonance of ^{239}Pu

Isobar	chain yield (%)
91	2.43
111	0.28 ± 0.04
112	0.130 ± 0.02
113	0.076 ± 0.011
115	0.024 ± 0.005
117	0.0181 ± 0.004

Table 4: Independent yields of ^{96}Nb, ^{98g}Nb, ^{130g}I and ^{136}Cs and fractional cumulative yield of ^{135}I in the thermal neutron induced fission of ^{249}Cf and corresponding values for Zp, Z_{UCD}, ΔZ and ν_A

Nuclide	Independent yield (%)	chain yield (%) {a}	Fractional yield	Zp {b}	ν_A {c}	Z_{UCD} {d}	ΔZ
^{96}Nb	$(4.4 \pm 0.6) \cdot 10^{-3}$	1.8 ± 0.3	$(2.4 \pm 0.7) \cdot 10^{-3}$	38.92 ± 0.21	1.5 ± 0.2	38.22	$+0.70 \pm 0.22$
^{98}Nb	0.15 ± 0.03	2.7 ± 0.3	$(5.6 \pm 1.2) \cdot 10^{-2}$	$>39.41 \pm 0.20$	1.5 ± 0.2	39.00	$+0.61 \pm 0.22$
^{130g}I	$(3.1 \pm 0.3) \cdot 10^{-2}$	2.6 ± 0.3	$(1.2 \pm 0.3) \cdot 10^{-2}$	>51.04	0.5 ± 0.1	51.16	>-0.14
^{135}I	3.3 ± 0.2 {e}	5.2 ± 0.5	0.64 ± 0.10 {e}	53.30 ± 0.15	1.6 ± 0.3	53.55	-0.21 ± 0.19
^{136}Cs	0.34 ± 0.02	5.5 ± 0.5	$(6.2 \pm 0.9) \cdot 10^{-2}$	53.64 ± 0.14	1.7 ± 0.3	53.98	-0.30 ± 0.18

{a} Average chain yields extrapolated from Flynn and von Gunten, Helv. Chim. Acta 52, 2216 (1969) and Kurchatov et al., Nucl. Phys. 14, 528 (1972)

{b} Most probable charge in a Gaussian charge distribution with $\sigma = 0.56 \pm 0.06$ taken from Wolfsberg LA-5553-Ms (1974)

{c} Extrapolated from Nifenecker et al., Proc. Symp. Phys. and Chem. of Fission (1973) for ^{252}Cf, corrected with $\frac{\bar{\nu}_{249}}{\bar{\nu}_{252}}$ from Unik et al. Proc. Symp. Phys. and Chem. of Fission (1973)

{d} $Z_{UCD} = (Z_F/A_F) \cdot (A + \nu_A)$

{e} Cumulative yield

III. Laboratorium für Kernphysik, Eidg. Technische Hochschule Zürich

(Dir.: Prof. Dr. J. Lang)

1. Investigation of the 1^+ resonance in ^6Li by d-α scattering between 6 and 7 MeV

W. Grüebler, V. König, R. Risler, B. Jenny, J. Nurzynski*, H. R. Bürgi, P. A. Schmelzbach and R. A. Hardekopf**

Deuteron-alpha elastic scattering is a popular reaction used to investigate the structure of ^6Li. Cross section measurements as well as vector and tensor analysing power measurements have been carried out up to nearly 50 MeV in small energy steps {1,2}. Phase shift analyses of these data show several well separated resonances, particularly in the energy range below 10 MeV. Of particular interest for the investigation of tensor forces is the 1^+ resonance, which occurs near an excitation energy of 5.7 MeV, corresponding to a deuteron energy of 6 to 7 MeV. In the phase shift analysis {1} a mixing between S and D-waves is observed for this 1^+ resonance. Such a coupling between orbital angular momenta with a difference of two units can only be caused by tensor interaction. In earlier measurements the energy steps in this region have been too large to determine the details of the mixing parameter.

In order to extract more accurate information about the tensor interaction, therefore, we have made precision measurements of the differential cross section σ_o, vector and tensor analysing powers iT_{11}, T_{20}, T_{21} and T_{22} in steps of 100 to 200 keV in the energy range 6 to 7 MeV. These independent observables are measured in the CM-system angular range between 11^o and 165^o.

The results are shown in figs. 1 to 3. The statistical errors of the measurements are at most the size of the dots. It is interesting to notice that all observable measured in the energy range of the 1^+ resonance do not show distinct variation of the angular distributions. So alone and without phase shift analysis one would not expect a resonance. This behaviour, however, is typical for broad resonances in light nuclei.

The curves in the figures are preliminary results of a phase shift analysis, where the mixing parameter ε is assumed to be real. The results of the analysis are described and discussed in {3}.

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{3} R. A. Hardekopf, W. Grüebler et al., Laboratorium für Kernphysik ETHZ, Jahresbericht (1976) 54

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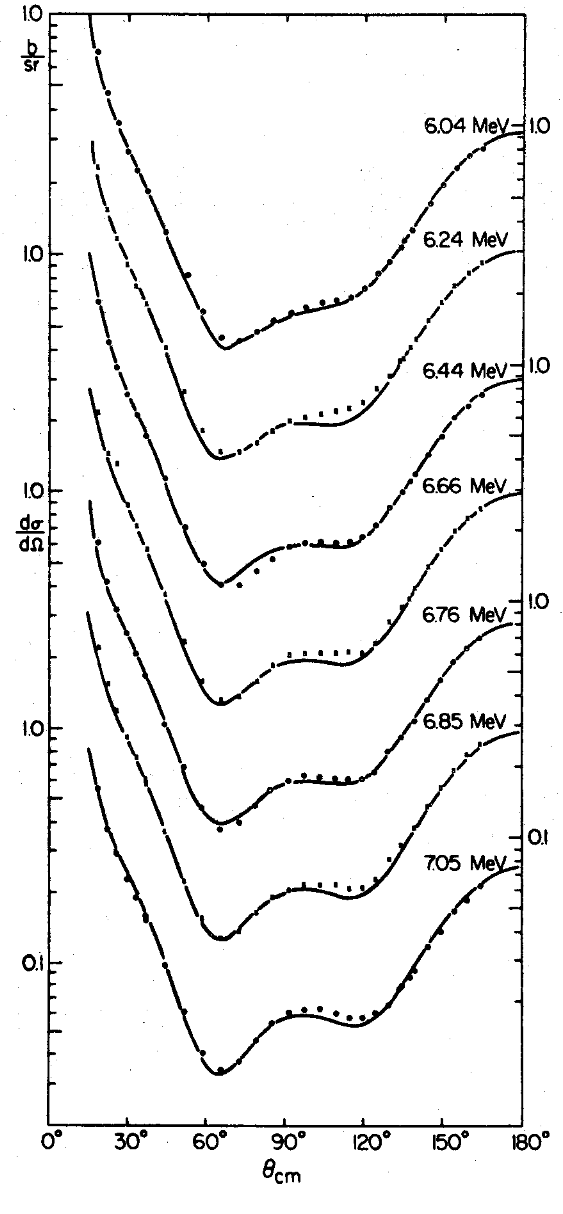

Fig. 1: Angular distributions of the differential cross section for d-α scattering between 6 and 7 MeV. The dots and crosses are larger than the statistical errors. The dots refer to the left side scale, the crosses to the right side scale. The curves are phase shift analysis fits.

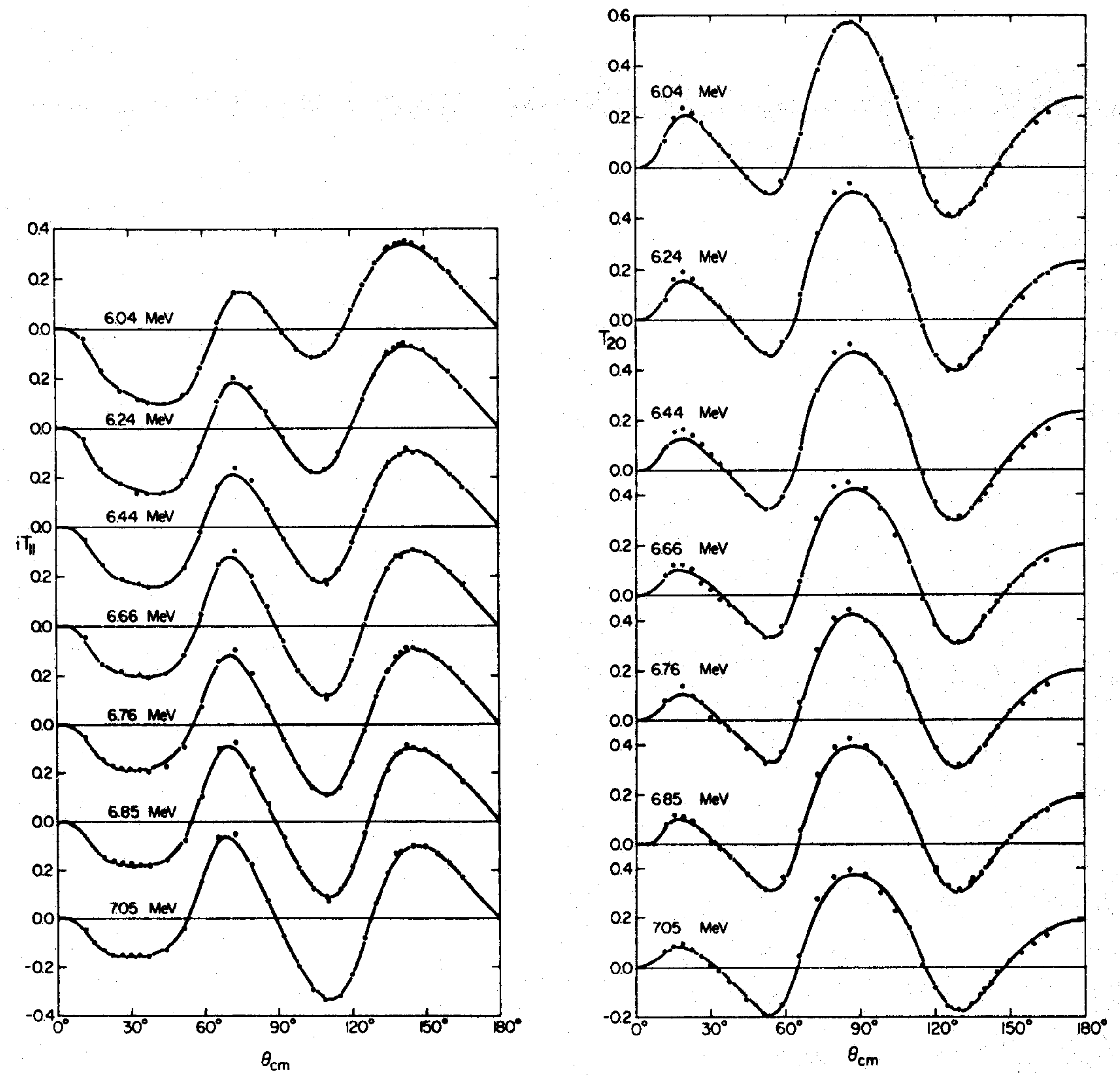

Fig. 2: The vector analysing power iT_{11} and the tensor analysing power T_{20} of d-α scattering between 6 and 7 MeV. The dots are larger than the statistical errors. The solid lines are phase shift analysis fits.

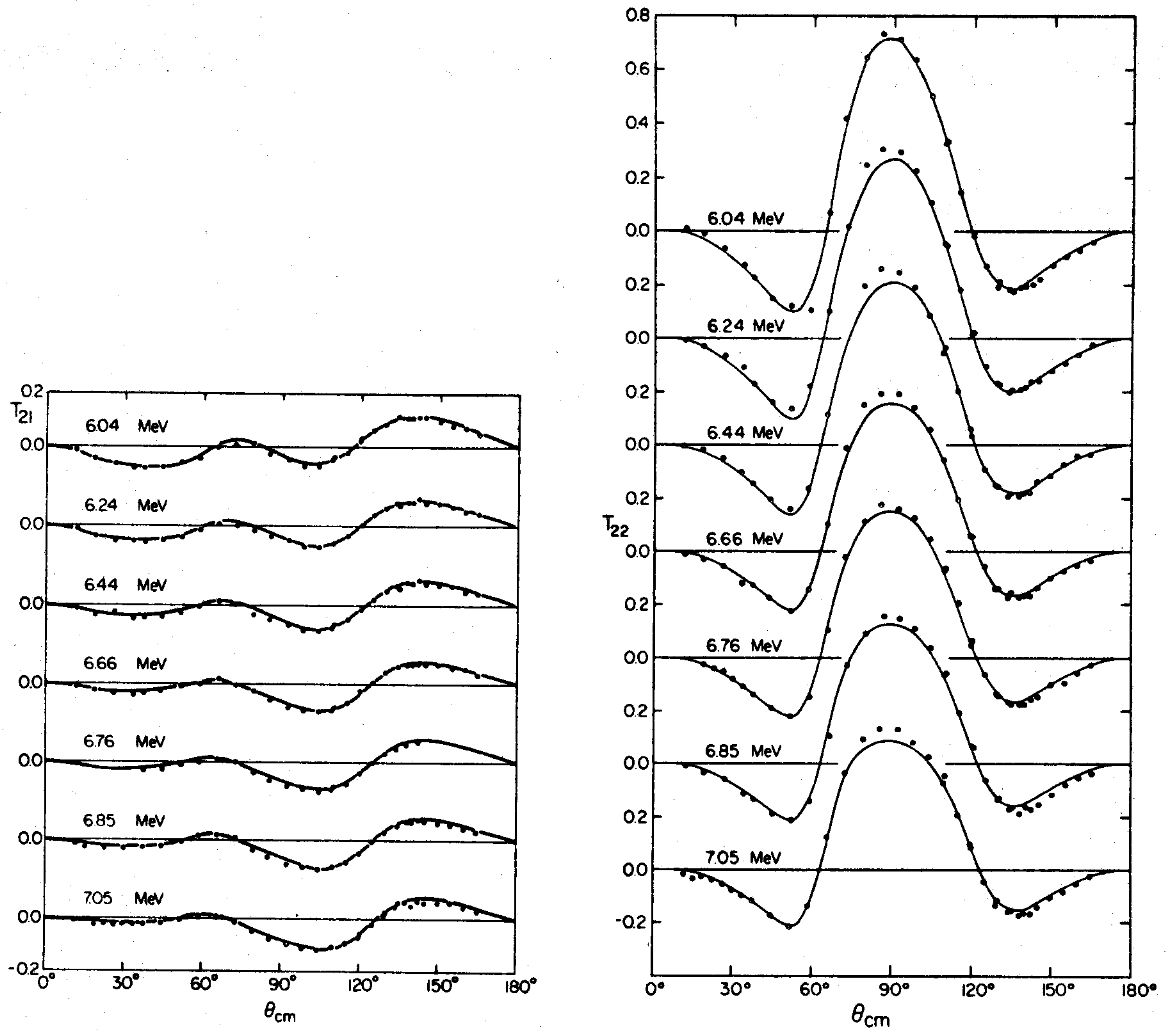

Fig. 3: The tensor analysing powers T_{21} and T_{22} of d-α scattering betwen 6 and 7 MeV. The dots are larger than the statistical errors. The solid lines are phase shift analysis fits.