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PROGRESS REPORT TO NEANDC FROM SWITZERLAND

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Swiss Federal Institute for Reactor Research
Würenlingen

~~NOT FOR PUBLICATION~~

PREFACE

CONTENTS

I. Institut de Physique, Université de Neuchâtel

(Dir.: Prof. Jean Rossel)

1. n-d elastic differential cross section at 2.48 and 3.38 MeV

P. Chatelain, Y. Onel and J. Weber

In 1977, we have completed the analysis of the data from the experiments described in the previous report. Preliminary results of these experiments have been published {1}. A detailed description of the method which we have used to measure the response and the resolution of the scatterers have also been published {2}. The final results will be soon submitted for publication. As we have expected, the partial waves higher than $\ell = 2$ are needed to fit forward angles data {3} and our data ($-1. \leqslant \cos\theta_{CM} \leqslant +0.5$). Phase shifts analyses of these data are in progress.

References

{1} P. Chatelain et al., Helv. Phys. Acta. Accepted for publication

{2} P. Chatelain et al., Nucl. Inst. Meth. Accepted for publication

{3} J. D. Seagrave et al., Phys. Rev. 105 (1957) 1816

2. Depolarization factor D(θ) for the $d(\vec{n},\vec{n})d$ reaction at 2.45 MeV

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

We hope to complete the measurements of the angular variation of D by the end of this year. The results of these measurements will be of great help in the better understanding of the doublet phase shifts for this reaction. Part of our results for D(θ) have already been published {1} as well as our results for A(θ) which had been previously obtained {2}.

Our cross section $D(\theta)$- and $A(\theta)$-results will be soon used as input data to extensive effective range {1} and phase shifts analyses.

{1} D. Bovet et al., J. of Physics G. Accepted for publication

{2} D. Bovet et al., Proceedings of the ICINN-Conference, Lowell 1976, part 2, p. 1357 (CONF - 760715-p2)

3. Three body reactions with ^{6}Li

F. Foroughi, E. Bovet, C. Nussbaum and B. Vuilleumier

During the last year, we measured the α-α quasifree scattering (QFS) in the ^{6}Li $(\alpha,\alpha\alpha)$d reaction at 59 MeV. The purpose of this experiment is to remove the kinematical degeneracy {1}.

Our measurement was monitored with the elastic reaction ^{6}Li (α,α)^{6}Li, which we measured with high accuracy (see fig. 1). These data are analysed with an optical potential. In order to match our data to the previously reported ones {2}, we repeated the measurement for three configurations ($\theta_1 = -\theta_2 = 44{,}15$, $\theta_1 = 35{,}15$, $\theta_2 = -53{,}1$ and $\theta_1 = 29{,}15$, $\theta_2 = -58{,}9$).

Our results do not agree with those quoted in {2} (see fig. 2). The critical configuration is that with $\theta_{CM} = 72^0$ ($\theta_1 = 35{,}15$, θ_2 $53{,}1$). If this result is confirmed, the mechanism would be then a final state interaction instead of a QFS one.

References

{1} E. Bovet, F. Foroughi, C. Nussbaum, B. Vuilleumier and J. Rossel, SIN Jahresbericht 1977, page E89

{2} J.W. Watson, H. G. Pugh, P. G. Roos, D. A. Goldberg, R. A. Riddle and D. I. Bonbright, Nucl. Phys. A172 (1971) 513

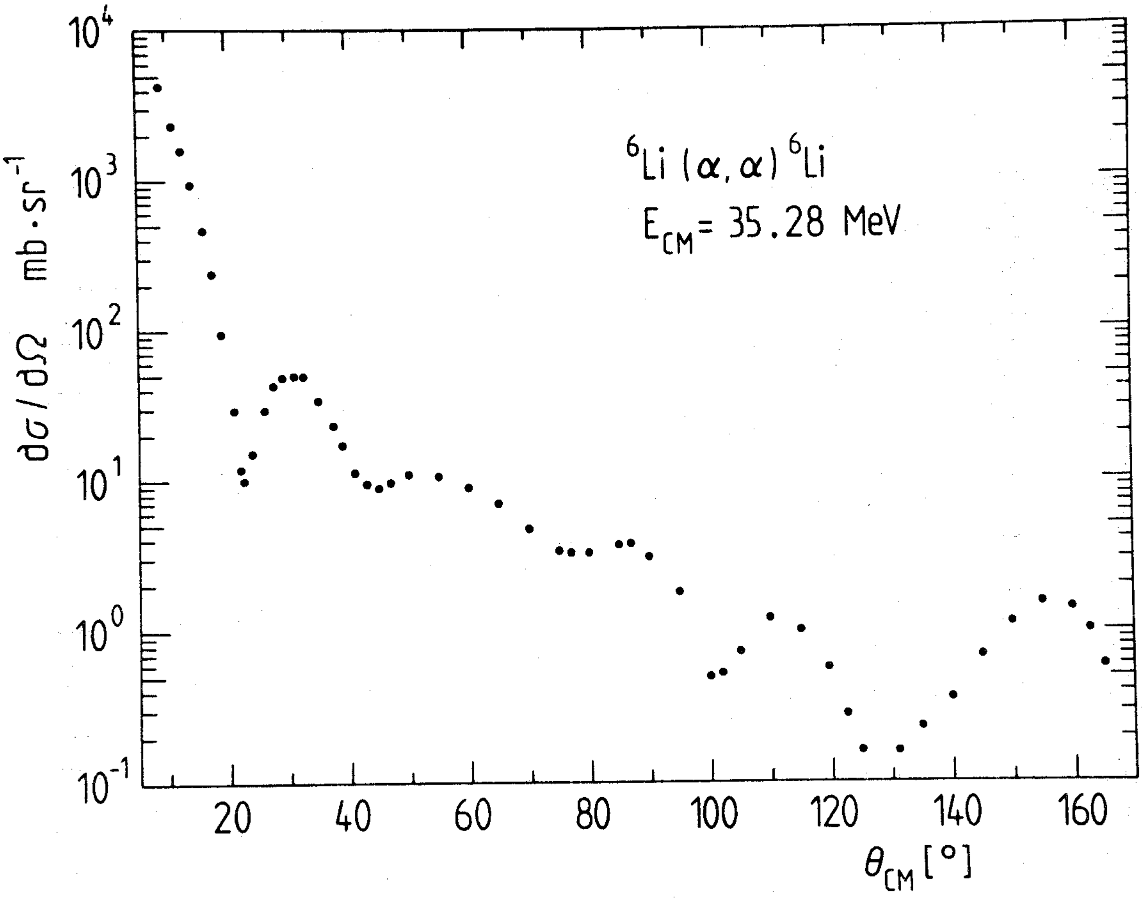

Fig. 1: Measured α-^6Li elastic cross section. The points are larger than the error bars.

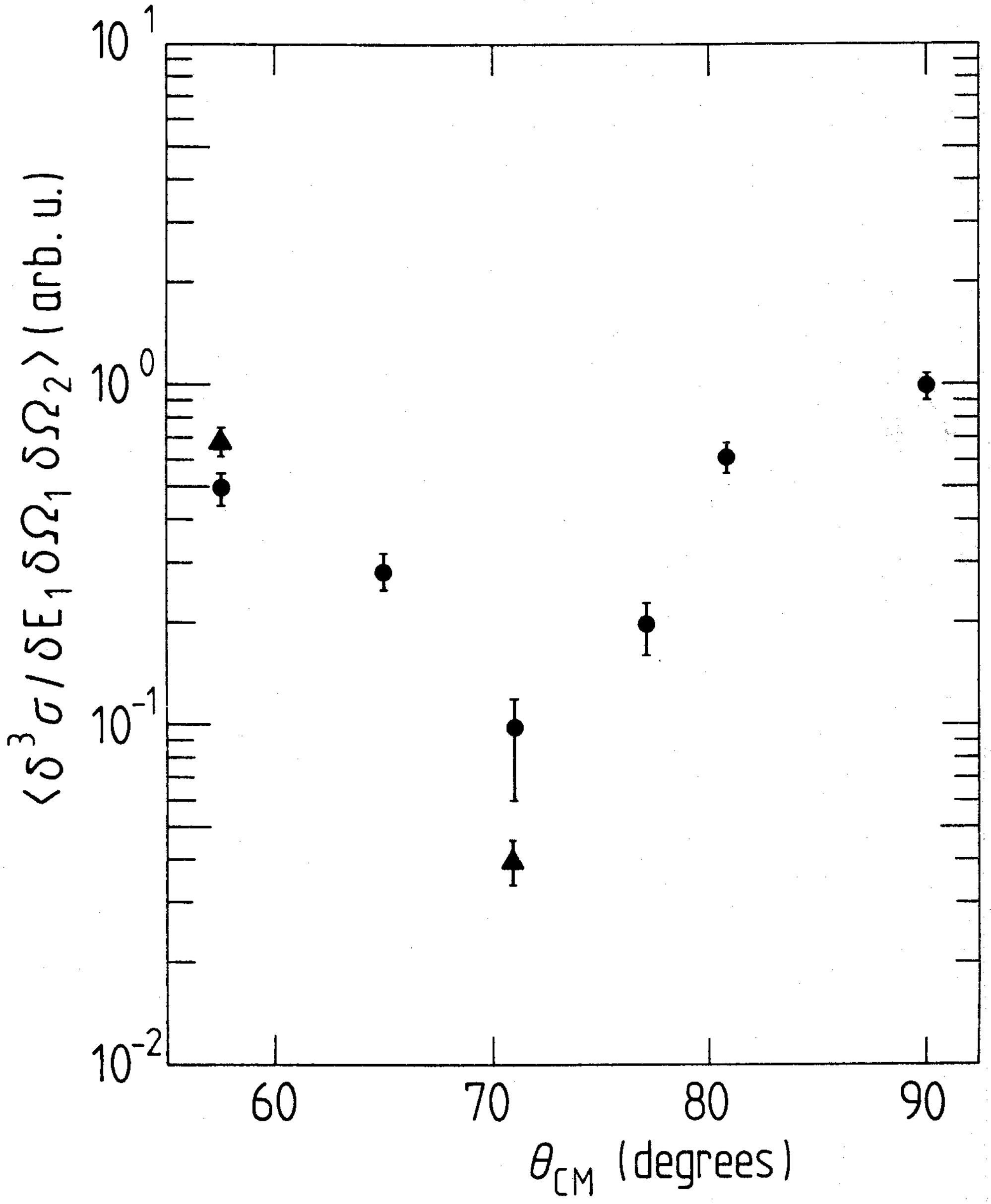

Fig. 2: QFS peak cross section for various configurations. Our data (triangle) were normalized to those of Watson {2} at $\theta_{CM} = 90^0$.

II. Eidg. Institut für Reaktorforschung, Würenlingen

Dir.: Prof. Dr. H. Gränicher

1. Independent yields of ^{148m}Pm and ^{148g}Pm in the thermal neutron-induced fission of ^{233}U and ^{239}Pu

H. U. Zwicky and H. R. von Gunten

Pm was separated from rare earths fission products using high pressure ion exchange chromatography (Aminex A5 cation exchanger, α-hydroxiisobutyric acid with pH gradient). The samples were measured with Ge(Li)-γ-ray spectroscopy ralative to ^{151}Pm and ^{149}Pm. The independent and fractional independent yields for ^{148m}Pm and ^{148g}Pm are shown in table 1.

Table 1: Independent and fractional independent yields for ^{148m}Pm and ^{148g}Pm in the thermal neutron-induced fission of ^{233}U and ^{239}Pu

Target nuclide	Independent yield (%)		Fractional independent yield (%)	
	^{148m}Pm	^{148g}Pm	^{148m}Pm	^{148g}Pm
^{233}U	$(7.8\pm1.4)\times10^{-7}$	$(1.8\pm0.4)\times10^{-7}$	$(6.1\pm1.1)\times10^{-7}$ a)	$(1.4\pm0.3)\times10^{-7}$ a)
^{239}Pu	$(4.3\pm0.7)\times10^{-6}$	$(1.3\pm0.3)\times10^{-6}$	$(2.6\pm0.4)\times10^{-6}$ b)	$(7.9\pm1.7)\times10^{-7}$ b)

a) Yield of chain 148: (1.271±0.006)% {1}

b) Yield of chain 148: (1.636±0.008)% {1}

Reference

{1} Meek and Rider, NEDO-12154

2. Spontaneous-fission half-lives of ^{234}U and ^{236}U

H. W. Reist and M. Baggenstos

The partial spontaneous-fission half-lives of ^{234}U and ^{236}U have been re-measured using the rotation chamber. The highly enriched uranium isotopes (^{234}U: 99.37 w/o; ^{236}U: 99.685 w/o) were loaned from the Argonne National Laboratory.

To reduce neutron induced fission the experiment was surrounded by 20 cm paraffin containing 16 w/o boron.

The following values were obtained:

$$^{234}U : T_{1/2} \text{ (sp. f.)} = (1.42 \pm 0.10) \times 10^{16} \text{ years}$$

$$^{236}U : T_{1/2} \text{ (sp. f.)} = (2.43 \pm 0.17) \times 10^{16} \text{ years}$$

3. Radiochemical investigation of the mass distribution and probability in stopped μ^- induced fission of ^{238}U

P. Baertschi, A. Grütter, H.R. von Gunten, H.S. Pruys*,
M. Rajagopalan**, H.W. Reist and E. Rössler

Radiochemical measurements of 24 fission products show that the mass-split is asymmetric in stopped μ^- induced fission of ^{238}U. The mass distribution is similar to 14 MeV neutron-induced fission. The main difference is a smaller peak-to-valley ratio indicating a mean excitation energy of about 20 MeV. The fission probability (prompt and delayed) is 0.15±0.03 per stopped muon.

For details confer publication in Nuclear Physics A294 (1978) 369.

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4. Half-life of ^{57}Mn

A. Wyttenbach, A. Schubiger, H.S. Pruys*

^{57}Mn and ^{58}Mn were produced by the reaction $^{59}Co\ (\mu^-, p)\,^{58}Mn$ and $^{59}Co\ (\mu^-, pn)\,^{57}Mn$ in the same target and their half-lives determined by gamma-ray-spectroscopy. The value for ^{58}Mn was found to be (65 ± 1)s in perfect agreement with literature values; contrarily the value for ^{57}Mn was found to be (86.7 ± 0.8)s, what is considerably less than previously reported values.

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III. Laboratorium für Kernphysik, Eidg. Technische Hochschule, Zürich

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

1. Elastic Scattering and neutron-transfer reactions with ^{9}Be

L. Jarczyk, B. Kamys, J. Lang, R. Müller, E. Ungricht and J. Unternährer

The elastic scattering of ^{9}Be on ^{9}Be, ^{12}C, ^{16}O and seven heavier target nuclei in the mass region between ^{24}Mg and ^{197}Au was measured at beam energies of 14, 20 and 26 MeV. In a sputtering ion source a BeO^{-} beam was produced, accelerated up to the terminal of the Tandem accelerator and converted to positive Be-ions in a gas stripper {1}.

The angular distributions of the scattering on light nuclei show distinct diffraction patterns. Calculations with fitted optical potentials give good agreement with the measurements on ^{12}C target in the angular range $\theta_{cm} < 90^0$ only. It seems that at bigger angles elastic transfer processes (^{3}He-transfer) are important.

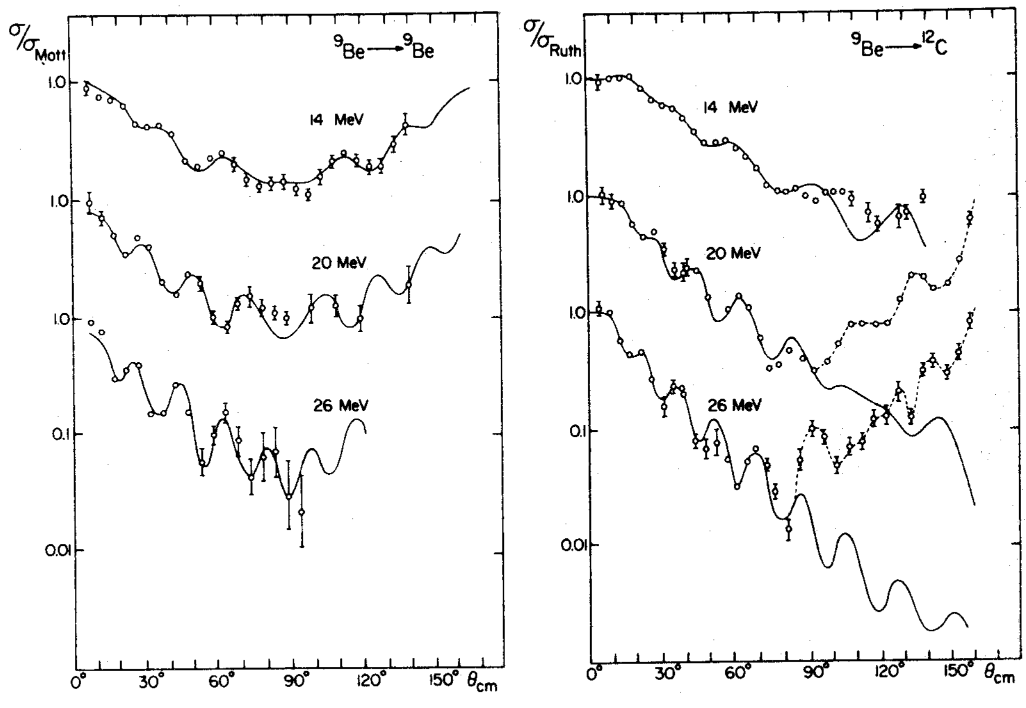


Fig. 1: Angular distribution of elastic scattering of ^{9}Be on ^{9}Be and ^{12}C. Solid lines: Optical model calculations. The dotted lines are only for guiding the eye.

The angular distributions of the scattering on heavier target nuclei could be reproduced at all angles and all energies by optical model calculations. The potentials were calculated with the Ansatz

$$U = V_c - (V_0 + iW_0)/f(r)$$
$$f(r) = 1 + \exp\{(r - R_n)/a\}$$
$$R_n = R_0 \cdot (A_t^{1/3} + A_b^{1/3}) - R_1$$

where the Coulomb potential was approximated by

$$V_c = \frac{Z_t Z_b e^2}{r} \qquad r \geq R_c$$
$$V_c = \frac{Z_t Z_b e^2}{2R_c}\left(3 - \left(\frac{r}{R_c}\right)^2\right) \qquad r \leq R_c$$
$$R_c = R_{c0} \cdot A_t^{1/3} \qquad R_{c0} = 1,2\ \text{fm}$$

It was possible to find a universal potential reproducing all angular distributions with good agreement. Because of the existence of an ambiguity the depth V_o of the real potential was fixed and the other parameters fitted. The obtained values are listed in table 1. Compared with other heavy ion potentials the great diffusiveness a and the big ratio W/V $\approx$ 2 are remarkable.

Table 1: Optical model parameters for elastic scattering of ^{9}Be on targets from ^{24}Mg to ^{197}Au

V_0	2.5	5.0	10.0	20.0	40.0	69.0	MeV
W_0	7.6 ± 0.3	11.8 ± 0.5	20.4 ± 0.8	37.5 ± 1.5	72.7 ± 2.8	130.0 ± 3.5	MeV
a	0.73 ± 0.01	0.78 ± 0.01	0.82 ± 0.01	0.85 ± 0.01	0.87 ± 0.01	0.89 ± 0.01	fm
R_0	1.26 ± 0.02	1.31 ± 0.02	1.34 ± 0.02	1.36 ± 0.02	1.37 ± 0.02	1.36 ± 0.02	fm
R_1	−0.83 ± 0.08	0.06 ± 0.09	0.91 ± 0.10	1.71 ± 0.10	2.45 ± 0.10	3.00 ± 0.10	fm
χ^2	2.13	1.90	1.83	1.83	1.84	1.90	

In addition, neutron-transfer reactions on ^{28}Si and ^{40}Ca targets leading to different bound states of ^{29}Si and ^{41}Ca were measured. The angular distributions were compared with finite range DWBA calculations. Unfortunately it was not possible to extract spin values for the levels in the final nuclei ^{29}Si and ^{41}Ca since the results are only weakly spin dependent. From levels with known spins and using known spectroscopic factors for these levels, a spectroscopic factor for ^{9}Be can be determined. The value found in this way amounts to $S(^{9}Be \rightarrow ^{8}Be + n) = 0.42 \pm 0.04$; it is lower than the theoretical value $S_{th} = 0.58$, though the accuracy of the latter is around 20 % {2}. The DWBA analysis is not sensitive to the optical model parameters as long as they reproduce well the elastic scattering.

References

{1} R. Balzer, Proc. Europ. Conf. on Nuclear Physics with Heavy Ions, Caen 1976

{2} S. Cohen and D. Kurath, Nucl. Phys. A101, 1 (1967)

2. Comparison of the mirror reactions $^{2}H(d,p)^{3}H$ and $^{2}H(d,n)^{3}He$

V. König, W. Grüebler, R.A. Hardekopf, B. Jenny, R. Risler and H.R. Bürgi

In previous comparisions of the polarizations of the outgoing nucleons in the mirror reactions $^{2}H(d,p)^{3}H$ and $^{2}H(d,n)^{3}He$ it was shown {1,2} that the proton polarizations are larger than the neutron polarizations. These sizable differences can be removed by lowering the deuteron energy for the (d,n) reaction by 1.5 MeV {1,2} to give a comparison for the same energy in the exit channels. To investigate similar effects in the analysing powers the observables iT_{11}, T_{20}, T_{21} and T_{22} were measured for both reactions with high precision in steps of 1.5 MeV between 2.5 and 11.5 MeV. The angular range of comparison is restricted to backward angles mainly by the experimental technique used for measuring the recoil ^{3}He for the (d,n) reaction. The experimental results have been fitted with Legendre polynomials. Fig. 1 compares the results of the (d,p) reaction with the fits of the mirror reaction at the same deuteron energy and shows discrepancies for T_{20} and T_{22}.

Fig. 2 compares the results of the (d,n) reaction with the fits of the (d,p) reaction at the same energy in the exit channels and shows better agreement for T_{20} and T_{22}, but strong deviations for iT_{11} and T_{21}. For a better overall comparison, the following average deviation is given in Fig. 3:

$$D_{av} = \int_{\theta_1}^{\theta_2} D_{kq}(\theta)d\theta/(\theta_2-\theta_1)$$

where: $D_{kq} = |T_{kq}(d,p)-T_{kq}(d,n)|$ and $\theta_1 = 100^0$ and $\theta_2 = 160^0$. This figure shows that when the correction for the Coulomb displacement proposed in {1,2} is applied the discrepancies persist. These almost energy independent discrepancies are observed in a region where Coulomb effects ought to be small (low charge of all particles, large energy of the emitted nucleons, backward hemisphere of scattering) and therefore a violation of charge symmetry should not be excluded from consideration. Although at the present time it seems too difficult to filter out the Coulomb effects in a proper way, hopefully the future will show if a combination of strong forces with charge symmetry property and electromagnetic forces can explain the present results. Model calculations of the ^4He excitations e. g. multichannel R-matrix calculations, should be helpful in the investigation of this most important question.

References

{1} R.A. Hardekopf, R.L. Walter and T.B. Clegg, Phys. Rev. Lett. 28 760 (1972)

{2} R.A. Hardekopf et al., Nucl. Phys. A191, 468 (1972)

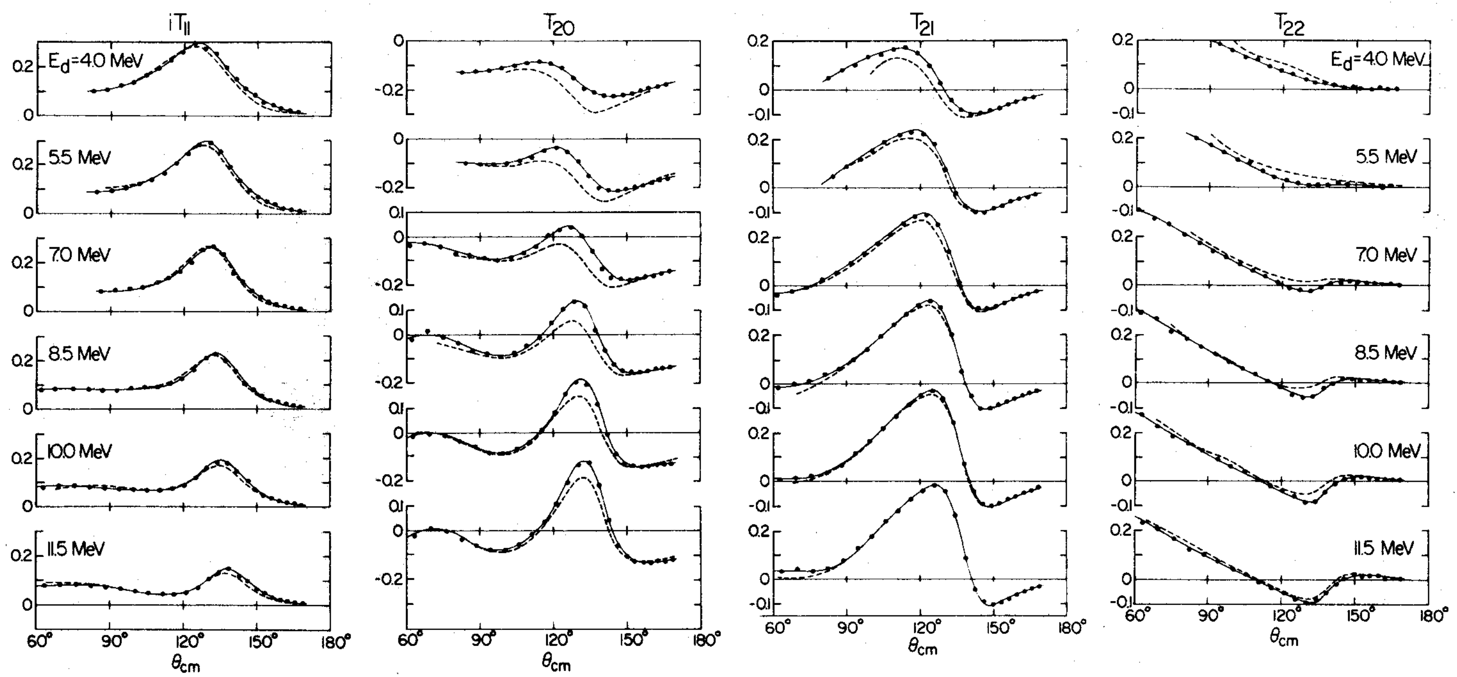
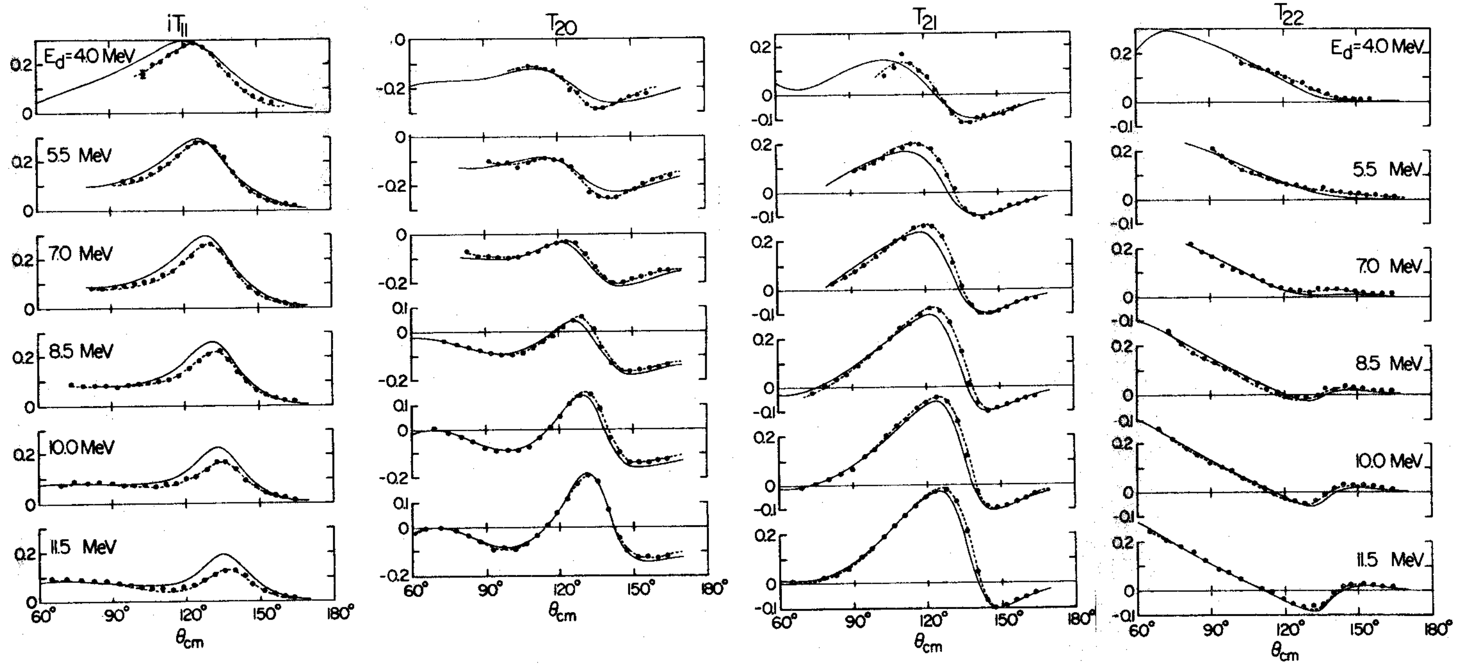
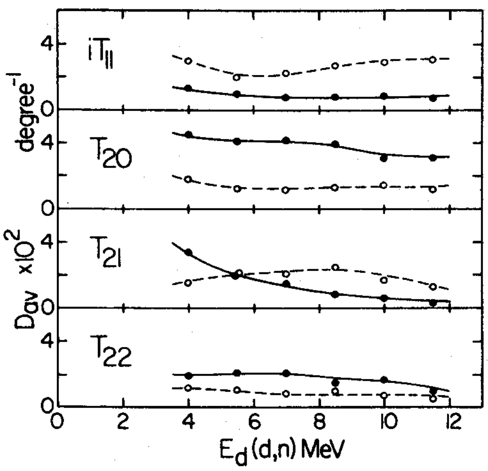


Fig. 1: Comparison of the analysing powers at the same deuteron energy. The dots are the results of the $^{2}H(d,p)^{3}H$ reaction, the solid curves fits to these data. The dashed curves are fits to the (d,n) reaction.



<u>Fig. 2:</u> Comparison of the analysing powers at the same exit energy of the nucleons. The dots are results of the $^{2}H(d,n)^{3}He$ reaction, the dashed curves fits to these data. The solid curves are fits to the (d,p) reaction, for deuteron energies lower by 1.5 MeV than the indicated energies.



<u>Fig. 3:</u> Average deviation D_{av} of the analysing powers for the mirror reactions as a function of energy. The dots represent comparisons at the same entrance energies, the circles at the shifted energies. The solid and dashed lines are drawn to guide the eye. The size of the dots and circles indicates the uncertainties in D_{av}.