No 1401/I/PL

INSTYTUT BADAŃ JĄDROWYCH
ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ
INSTITUTE OF NUCLEAR RESEARCH

REPORT

No 1401/I/PL

PROGRESS REPORT ON NUCLEAR DATA RESEARCH IN POLAND

/MAY 1971 —— APRIL 1972/

GATHERED BY
A. MARCINKOWSKI

WARSZAWA

1972

Распространяет:
ИНФОРМАЦИОННЫЙ ЦЕНТР ПО ЯДЕРНОЙ ЭНЕРГИИ
при Уполномоченном Правительства ПНР
по Использованию Ядерной Энергии
Дворец Культуры и Науки
Варшава, ПОЛЬША

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OŚRODEK INFORMACJI O ENERGII JĄDROWEJ
Pełnomocnika Rządu d/s Wykorzystania Energii Jądrowej
Warszawa, Pałac Kultury i Nauki

Wydaje Instytut Badań Jądrowych

Nakład 575 egz., Objętość ark. wyd. 2,06, Ark. druk 3, Data złożenia maszynopisu przez autora 25. IV. 1972, Oddano do druku 28.IV.1972 Druk ukończono V.1972r.,SP-09/250/66, Zam. nr 149/72

Editor's Note

This progress Report on nuclear data research in Poland (May 1971 - April 1972) contains only information on research, which is closely related to the activities of the International Data Committee of the International Atomic Energy Agency in the field of neutron physics. It does not include any information about other nuclear research as for example in the field of charged particles nuclear physics or the use of neutrons for solid state physics studies.

The individual reports are not intended to be complete or formal, and must not be quoted in publications without the permission of the authors.

Uwagi od wydawcy

Raport ten zawiera wyłącznie informacje o badaniach w zakresie fizyki neutronowej przeprowadzonych w Polsce (maj 1971 - kwiecień 1972) i związanych z działalnością Komitetu Danych Jądrowych Międzynarodowej Agencji Energii Atomowej.

Pominięto wyniki badań w innych dziedzinach fizyki jądrowej, w tym również badań prowadzonych przy użyciu cząstek naładowanych oraz w zakresie fizyki ciała stałego przy użyciu neutronów.

Poszczególne prace zawierają wstępne omówienie wyników badań nie wyczerpujące poruszanych tematów i nie powinny być cytowane bez uzyskania zgody autorów.

Замечания от редакции

Сборник этот содержит лишь сообщения о проведенных в Польше в период от мая 1971 до апреля 1972 исследованиях в области нейтронной физики, связанных с деятельностью Комитета по Ядерным Данным Международного Агенства Атомной Энергии. В данных не включены результаты работ из других областей ядерной физики а именно результаты исследований с помощью зараженных частиц а также с области применения нейтронов в физике твердого тела. Доклады эти не являются полными и не рекомендируется ссылаться на них без согласия авторов.

CONTENTS

"Cross-Sections for the $^{85}Rb(n,2n)^{84g,m}Rb$, $^{87}Rb(n,2n)^{86g,m}Rb$ and $^{117}Sn(n,np)^{116}In$ Reactions in the Neutron Energy Range 13-17 MeV".

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The absolute cross-sections for $^{85}Rb(n,2n)^{84g,m}Rb$, $^{87}Rb(n,2n)^{86g,m}Rb$ and $^{117}Sn(n,np)^{116}In$ reactions were evaluated from the γ-activity measurements with the use of a scintillation spectrometer. The reaction final products were identified by their characteristic γ-ray transitions and the least square analysis of the decay curves. The neutrons were obtained in the Van de Graaff accelerator from the $T(d,n)^4He$ reaction. The measurements were refered to the well known cross-sections of the $^{56}Fe(n,p)^{56}Mn$ and $^{64}Zn(n,2n)^{63}Zn$ reactions [1,2]. The results are shown in tables 1-3. The errors are the statistical errors only.

References:

1) D.C.Santry and J.P.Butler, Can.J.Phys. 42(1964)1030.

2) BNL 325 Supplement No 2, p.30-64-2.

Table 1

Cross Sections for the $^{85}Rb(n,2n)^{84g,m}Rb$ Reaction

	σ_g (mb)	σ_m (mb)
13.0 ± 0.2	398 ± 64	370 ± 11
13.3 ± 0.1	439 ± 26	405 ± 13
13.8 ± 0.1	639 ± 28	468 ± 8
14.5 ± 0.1	759 ± 40	491 ± 11
15.1 ± 0.2	648 ± 46	530 ± 23
15.4 ± 0.2	483 ± 28	525 ± 12
16.0 ± 0.2	700 ± 83	603 ± 53
16.6 ± 0.1	867 ± 116	600 ± 16
17.8 ± 0.1		671 ± 20

Table 2

Cross Sections for the $^{117}Sn(n,np)^{116}In$ Reaction

	σ(mb)
13.9 ± 0.1	1.17 ± 0.11
14.1 ± 0.2	1.23 ± 0.07
14.5 ± 0.1	1.26 ± 0.17
15.1 ± 0.2	2.03 ± 0.26
15.4 ± 0.2	1.80 ± 0.21
16.6 ±-0.1	6.4 ± 2.6

Table 3

Cross Sections for the $^{87}Rb(n,2n)^{87g,m}Rb$ Reaction

	σ_g (mb)	σ_m (mb)
13.0 ± 0.2		295 ± 39
13.3 ± 0.1	589 ± 71	501 ± 48
13.8 ± 0.1	636 ± 83	491 ± 40
14.5 ± 0.1	789 ± 67	518 ± 40
15.1 ± 0.2	525 ± 110	601 ± 20
15.4 ± 0.2	546 ± 100	630 ± 20
16.0 ± 0.2		522 ± 64
16.6 ± 0.1		567 ± 56

Excitation of isomeric activities in $^{131,133,135}Ba$ using 14.8 MeV neutrons

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Introduction

It is of interest to investigate the cross sections for excitation of isomeric activities in Ba in order to obtain more reliable information on the possible trend of the isomeric cross section against the neutron number of the residual nucleus performed under the same experimental conditions. The ^{129m}Ba and ^{137m}Ba fall near the opposite ends of this chain. The decay scheme of ^{129m}Ba is not well known. The cross section for excitation of ^{137m}Ba was determined in our earlier work [1].

Table 1

Cross sections for /n,2n/ and /nn'γ/ reactions

with 14.8 MeV neutrons from the present work

Target, reactions and isomeric nucleus	Half life	E_{γ} keV	Conversion coefficient	Measured cross section /mb/
$^{132}Ba/n,2n/^{131m}Ba$	14.6 min	107	0.9 ± 0.15	596 ± 120
$^{134}Ba/n,2n/^{133m}Ba$	38.9 h	276	3.45 ± 0.20	827 ± 80
$^{136}Ba/n,2n/^{135m}Ba$ $^{135}Ba/nn'\gamma/^{135m}Ba$	28.7 h	268	3.82 ± 0.20	1294 ± 120

Experimental procedure

The cross section measurements were carried out by the activation method. Natural "specpure" barium was irradiated by 14.8 MeV neutrons from the neutron generator. The neutron flux was monitored by counting the alpha particles from $T/d,n/^{4}He$ reaction with the help of solid state detector. The activities of the irradiated samples were measured using 8 cm^3 Ge/Li/ and 1.5" x 1" NaI/Tl/ gamma-ray detectors.

Results

Table 1 summarizes the cross-sections obtained in the present work together with the values of half-lives, gamma-ray energies and conversion coefficient used in the calculations. The estimated error in our measurements is of the order of ±10% for $^{133,135}Ba$ and ±20% for ^{131}Ba.

Discussion

In this work only the metastable state cross sections σ_m was measured. The experimental total cross sections σ_{tot} /$\sigma_{tot} = \sigma_m + \sigma_g$, σ_g - ground state cross section/ is known only for $^{132}Ba/n,2n/^{131}Ba$ / $T_{1/2}$ = 11 d / [2] and cannot be determined by activation method for $^{134}Ba/n,2n/^{133}Ba$ /very long half-life equal 7.7 y / and $^{136}Ba/n,2n/^{135}Ba$ /stable/. Recently Pearlstein [3] computed total cross sections at neutron energies 13.1, 14.1 and 15.1 MeV for large number of isotopes which agree excellently with the available experimental data. The errors of these semiempirical predictions have been assumed to be as large as ±15%. Using our results for σ_m and Pearlstein's predictions for σ_{tot} we can estimate the "experimental" isomeric cross ratios $\frac{\sigma_m}{\sigma_{tot}}$. The theoretical isomeric cross section ratios were calculated on the basis of the statistical theory of nuclear reactions using the method described by Huizenga and Vandenbosch [4] /Table 2/. This method is restricted to compound type reactions only. The compound nucleus mechanism for /n,2n/ reaction is well established. The values of penetrability factors for neutrons were taken from ref. [5].

Table 2

Isomeric cross section ratios for $^{131,133,135,137}Ba$

Reaction	I_m	I_g	σ_m exp. /mb/	σ_{tot} estim. from [3] /mb/	$\left(\frac{\sigma_m}{\sigma_{tot}}\right)_{exp}$	$\left(\frac{\sigma_m}{\sigma_{tot}}\right)_{calc.}$
$^{132}Ba/n,2n/^{131}Ba$	$11/2^-$	$1/2^+$	696	1690±15%	0.41±0.09	0.51
$^{134}Ba/n,2n/^{133}Ba$	$11/2^-$	$1/2^+$	827	1720±15%	0.48±0.08	0.62
$^{136}Ba/n,2n/^{135}Ba$	$11/2^-$	$3/2^+$	1294	1725±15%	0.75±0.13	0.62
$^{138}Ba/n,2n/^{137}Ba$	$11/2^-$	$3/2^+$	1048	1900±15%	0.55±0.1	0.63

The composite model for nuclear level densities proposed by Gilbert and Cameron [6] was used in computations.

Fig. 1a shows the metastable state cross sections measured in this work /together with the cross sections for excitation of ^{137m}Ba in /n,2n/ reaction taken from our earlier work [1] /plotted as a function of neutron number for constant spin value of isomeric level. It can be seen from this figure that the measured metastable cross section for ^{135m}Ba deviate considerably from other values. On the other hand the calculated isomeric cross section ratios follow a smooth curve /fig. 1b/ when plotted as a function of neutron number. Calculated and experimental isomeric ratios are in agreement within the experimental errors. A possible explanation for the deviation of cross section for excitation of ^{135m}Ba lies in the strong contribution of $^{135}Ba/nn'\gamma/^{135m}Ba$ process to /n,2n/ reaction. Although the separated isotope of ^{135}Ba was not available in the present work an attempt to estimate the /nn'γ/ cross section for ^{135}Ba was made. From Fig. 1a is seen that the

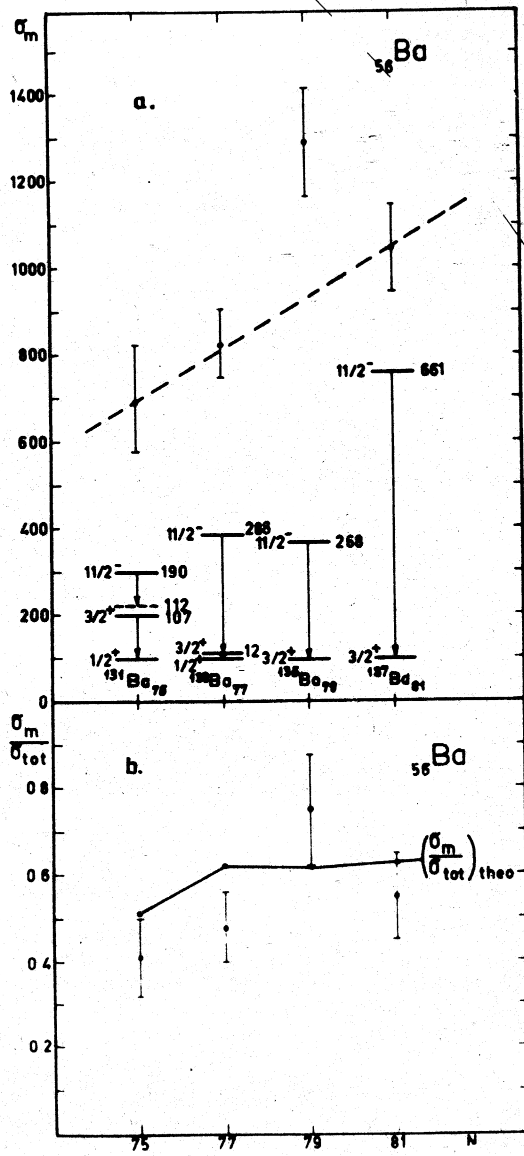

Fig.1.a/The cross sections for excitation of / $11/2^-$/ isomeric levels in odd-A isotopes of Ba by 14.8 MeV neutrons in /n,2n/ reaction as a function of neutron number. b/ The calculated and experimental values of isomeric ratios for these same isotopes as a function of neutron number.

value of metastable cross section for $^{136}Ba/n,2n/$ ^{135m}Ba reaction is about 950 mb. The constancy of theoretical isomeric cross section ratio /fig. 1b/ for neighbouring nuclei of ^{135}Ba suggests a similar value for this nucleus. Using the theoretical isomeric cross section ratio and Pearlsteins total cross section for $^{136}Ba/n,2n/^{135}Ba$ reaction at 14.8 MeV neutron energy it is possible to estimate σ_m cross section as not higher than 1080 mb. The experimental value for $^{136}Ba/n,2n/^{135m}Ba+^{135}Ba$ $/nn'\gamma/^{135m}Ba$ reaction is 1294 mb. Comparison of these two values and errors yields the upper limit for contribution of the $^{135}Ba/nn'\gamma/$ reaction as <500 mb. To establish a trend in the σ_m cross section for the /n,2n/ reaction as a function of the neutron number N, one has to disregard the experimental point corresponding to the ^{135}Ba, since in this case exist an essential contribution from the $/nn'\gamma/$ process. Through the remaining three points one may draw a streight line, as shown in fig. 1a, which corresponds to the systematic increase of σ_m with N.

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"Differential cross sections for the (n,α) reactions in ^{160}Dy, ^{162}Dy and ^{164}Dy at 14 and 18 MeV".

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The absolute differential cross sections for the $^{160}Dy(n,\alpha)^{157}Gd$, $^{162}Dy(n,\alpha)^{159}Gd$ and $^{164}Dy(n,\alpha)^{161}Gd$ reactions have been measured at two neutron energies $14.12\,^{+0.12}_{-0.08}$ and 18.15 ± 0.12 MeV by direct registration of the alpha particles. The alphas were detected by n-type surface barrier detectors. The experimental arrangement used in the measurements is described in our earlier work [1]. The neutrons were obtained from $^{3}H(d,n)^{4}He$ reaction with deuterons accelerated in the Van de Graaff accelerator. The neutron flux measured by counting the recoil protons from a thin polyethylene foil. The absolute calibration of the monitor was performed by measuring of the 847 keV γ-transition in

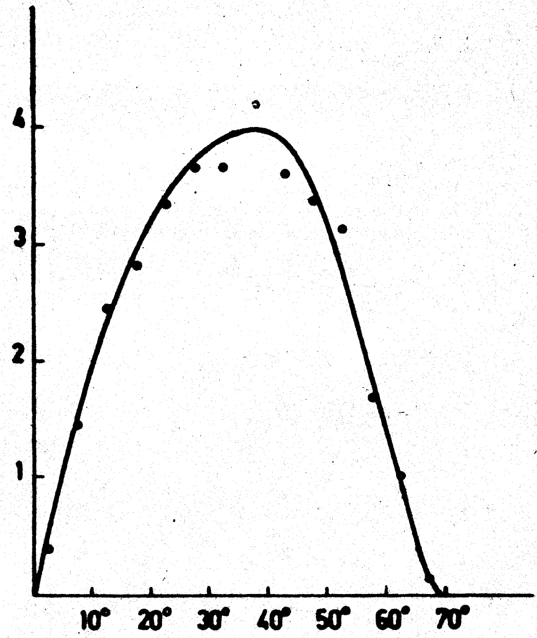
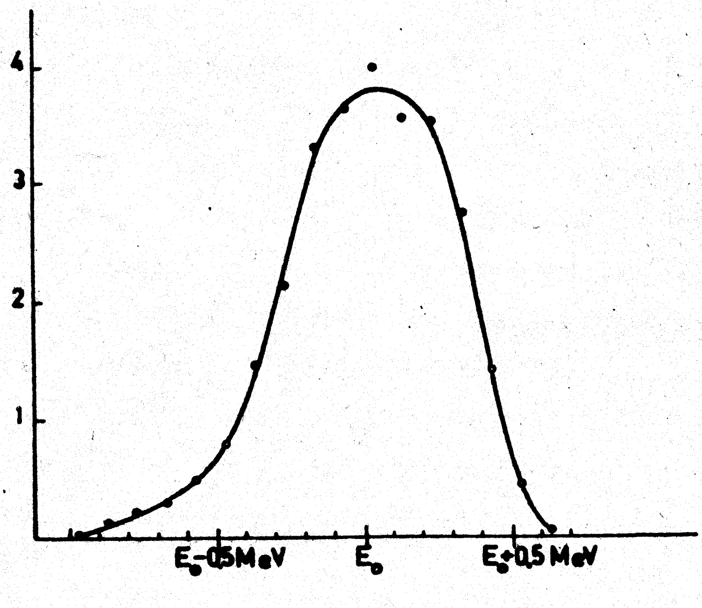


fig. 1



^{56}Fe produced in $^{56}Fe(n,p)^{56}Mn$ reaction with succesive β-decay of ^{56}Mn. The cross section for $^{56}Fe(n,p)^{56}Mn$ reaction was taken as 110 mb and 57 mb for neutron eneregies equal to 14.12 and 18.15 respectively [2].

The results of differential cross section measurements are shown in tables 1-6. Cross sections were measured with the angular spread shown in fig.1 and the total experimental energy spread of alpha particles shown in fig.2. The errors indicated in the tables are statistical. In tables 1-6 the cross sections integrated over whole alpha particle spectrum are also shown.

References

1. M.Jaskóła, J.Turkiewicz, L.Zemło, W.Osakiewicz, Acta Phys.Pol. B2,521(1971).

2. D.C.Santry, J.Butler, Can.J.Phys. 42,1030(64).

Table 1

Differential Cross Sections for the $^{160}Dy(n,\alpha)^{157}Gd$ Reaction at 14.12 MeV.

E_α(MeV)	$\mu b \cdot sr^{-1} MeV^{-1}$	E_α(MeV)	$\mu b \cdot sr^{-1} MeV^{-1}$
16.36	78 ± 34	19.40	123 ± 46
16.57	58 ± 30	19.61	103 ± 40
16.78	27 ± 22	19.84	133 ± 50
16.99	69 ± 30	20.05	159 ± 59
17.21	59 ± 28	20.26	156 ± 57
17.44	100 ± 41	20.47	159 ± 58
17.68	94 ± 38	20.68	133 ± 50
17.88	85 ± 34	20.89	136 ± 50
18.10	77 ± 32	21.01	112 ± 42
18.31	77 ± 32	21.13	89 ± 35
18.51	107 ± 41	21.25	63 ± 27
18.74	99 ± 38	21.37	34 ± 14
18.96	115 ± 44	21.58	15 ± 8
19.18	81 ± 32	21.79	1 ± 5

Integrated cross section = 0.51 ± 0.20 $mb.sr^{-1}$

Table 2

Differential Cross Sections for the $^{162}Dy(n,\alpha)^{159}Gd$ Reaction at 14.12 MeV.

E_α(MeV)	$\mu b.sr^{-1}MeV^{-1}$	E_α(MeV)	$\mu b.sr^{-1}MeV^{-1}$
15.37	26 ± 24	18.37	93 ± 36
15.57	23 ± 23	18.57	90 ± 35
15.77	9 ± 22	18.77	103 ± 40
15.97	25 ± 21	18.97	111 ± 43
16.17	46 ± 27	19.17	96 ± 37
16.37	26 ± 20	19.37	97 ± 37
16.57	34 ± 21	19.57	93 ± 35
16.77	43 ± 22	19.77	84 ± 32
16.97	36 ± 20	19.97	39 ± 16
17.17	42 ± 22	20.17	37 ± 16
17.37	36 ± 19	20.37	19 ± 10
17.57	56 ± 24	20.57	9 ± 6
17.77	63 ± 27	20.77	6 ± 5
17.97	77 ± 32	20.97	4 ± 4
18.17	73 ± 29		

Integrated cross section = 0.30 ± 0.11 $mb.sr^{-1}$

Table 3

Differential Cross Sections for the $^{164}Dy(n,\alpha)^{161}Gd$ Reaction at 14.12 MeV.

E_α (MeV)	$\mu b.sr^{-1}MeV^{-1}$	E_α (MeV)	$\mu b.sr^{-1}MeV^{-1}$
16.02	11 ± 13	18.32	46 ± 19
16.20	34 ± 17	18.51	43 ± 19
16.40	10 ± 11	18.70	45 ± 19
16.59	15 ± 11	18.88	41 ± 17
16.79	39 ± 17	19.07	50 ± 21
16.98	10 ± 6	19.26	48 ± 20
17.17	17 ± 10	19.44	40 ± 17
17.36	31 ± 15	19.64	29 ± 13
17.55	30 ± 14	19.83	32 ± 14
17.74	27 ± 14	20.01	24 ± 10
17.93	42 ± 18	20.21	12 ± 7
18.12	32 ± 15	20.39	2 ± 4

Integrated cross section $= 0.13 \pm 0.07$ $mb.sr^{-1}$

Table 4

Differential Cross Sections for the $^{160}Dy(n,\alpha)^{157}Gd$ Reaction at 18.15 MeV

E_α(MeV)	$\mu b.sr^{-1}MeV^{-1}$	E_α(MeV)	$\mu b.sr^{-1}MeV^{-1}$
18.80	79 ± 33	22.40	80 ± 18
19.00	63 ± 23	22.60	66 ± 16
19.20	88 ± 24	22.80	116 ± 23
19.40	70 ± 21	23.00	85 ± 18
19.60	83 ± 23	23.20	91 ± 19
19.80	129 ± 28	23.40	94 ± 19
20.00	91 ± 23	23.60	86 ± 18
20.20	66 ± 20	23.80	91 ± 18
20.40	94 ± 22	24.00	91 ± 18
20.60	81 ± 20	24.20	98 ± 19
20.80	77 ± 19	24.40	76 ± 15
21.00	99 ± 22	24.60	58 ± 12
21.20	96 ± 21	24.80	42 ± 10
21.40	95 ± 21	25.00	16 ± 6
21.60	77 ± 18	25.20	9 ± 5
21.80	89 ± 20	25.40	3 ± 4
22.00	82 ± 19	25.60	5 ± 3
22.20	66 ± 16		

Integrated cross section = 0.53 ± 0.08 $mb.sr^{-1}$

Table 5

Differential Cross Sections for the $^{162}Dy(n,\alpha)^{159}Gd$

Reaction at 18.15 MeV.

E_α(MeV)	$\mu b.sr^{-1}MeV^{-1}$	E_α(MeV)	$\mu b.sr^{-1}MeV^{-1}$
19.10	50 ± 24	21.90	65 ± 18
19.30	56 ± 24	22.10	64 ± 17
19.50	52 ± 23	22.30	62 ± 17
19.70	74 ± 24	22.50	81 ± 19
19.90	74 ± 23	22.70	57 ± 16
21.10	68 ± 22	22.90	75 ± 17
20.30	73 ± 22	23.10	70 ± 17
20.50	72 ± 21	23.30	65 ± 16
20.70	51 ± 20	23.50	67 ± 16
20.90	69 ± 21	23.70	79 ± 17
21.10	81 ± 21	23.90	39 ± 11
21.30	58 ± 18	24.10	19 ± 9
21.50	55 ± 18	24.30	29 ± 9
21.70	64 ± 18	24.50	17 ± 7

Integrated cross section = 0.34 ± 0.06 $mb.sr^{-1}$

Table 6

Differential Cross Sections for the $^{164}Dy(n,\alpha)^{161}Gd$ Reaction at 18.15 MeV.

E_{α}(MeV)	$\mu b.sr^{-1}MeV^{-1}$	E_{α}(MeV)	$\mu b.sr^{-1}MeV^{-1}$
18.85	51 ± 37	21.45	14 ± 15
19.05	46 ± 27	21.65	49 ± 18
19.25	50 ± 26	21.85	54 ± 18
19.45	13 ± 23	22.05	53 ± 17
19.65	55 ± 24	22.25	48 ± 16
19.85	55 ± 23	22.45	67 ± 18
20.05	36 ± 21	22.65	56 ± 17
20.25	40 ± 20	22.85	54 ± 15
20.45	63 ± 22	23.05	26 ± 12
20.65	31 ± 19	23.25	32 ± 12
20.85	47 ± 20	23.45	17 ± 10
21.05	48 ± 19	23.65	7 ± 8
21.25	35 ± 18	23.85	6 ± 3

Integrated cross section = 0.21 ± 0.04 $mb.sr^{-1}$

"Energy distributions of alpha particles from $^{160}Dy(n,\alpha)^{157}Gd$, $^{162}Dy(n,\alpha)^{159}Gd$ and $^{164}Dy(n,\alpha)^{161}Gd$ reactions at 18 MeV".

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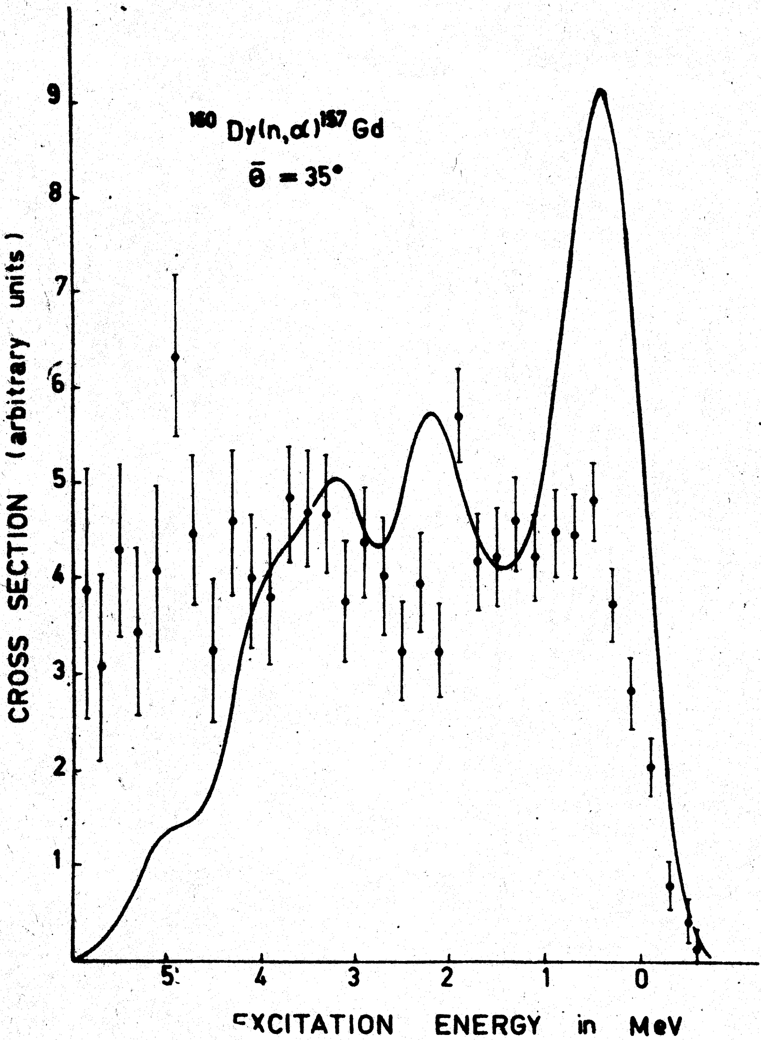
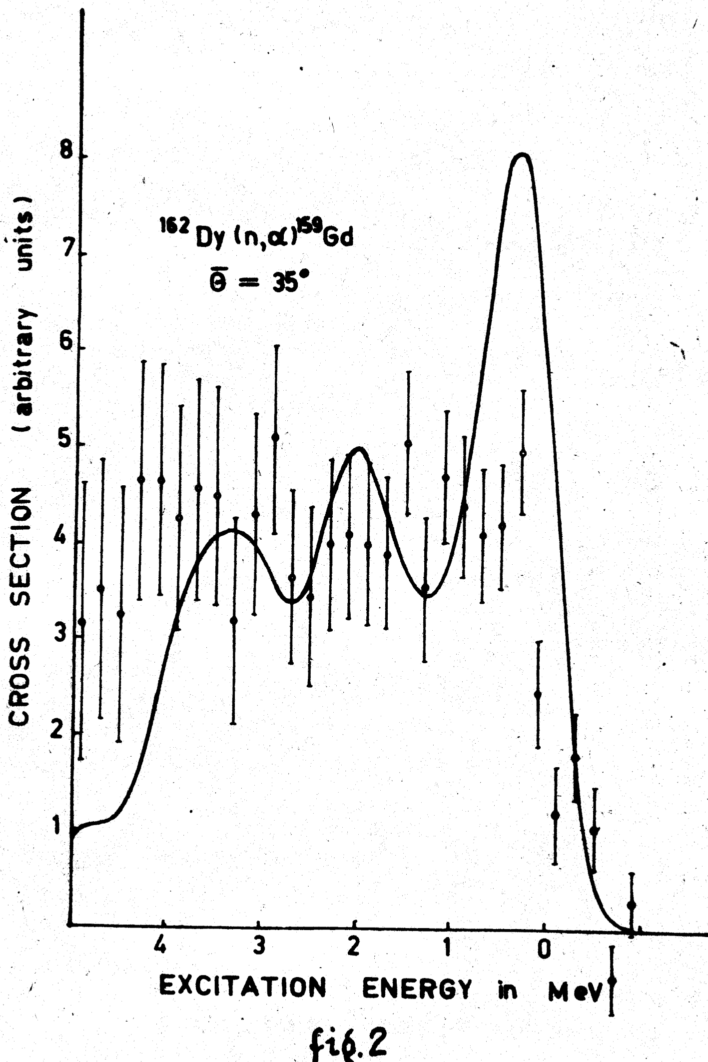
Using semiconductor α-particle spectrometer [1] the energy distributions of alpha particles from $^{160}Dy(n,\alpha)^{157}Gd$, $^{162}Dy(n,\alpha)^{159}Gd$ and $^{164}Dy(n,\alpha)^{161}Gd$ reactions at 18.15 ± 0.12 MeV have been measured. The neutrons were obtained from $^{3}H(d,n)^{4}He$ reaction with deuterons accelerated in the Van de Graaff accelerator. The flux of neutrons was monitored by counting the recoil protons knocked from a thin polyethylene foil. Recoil protons were registered by a CsI(Tl) scintillator followed by photomultiplier and standard electronics. The accuracy of neutron monitoring was better than 2%.

Samples of ^{160}Dy, ^{162}Dy and ^{164}Dy were made of oxides and deposited on thick carbon backings by means



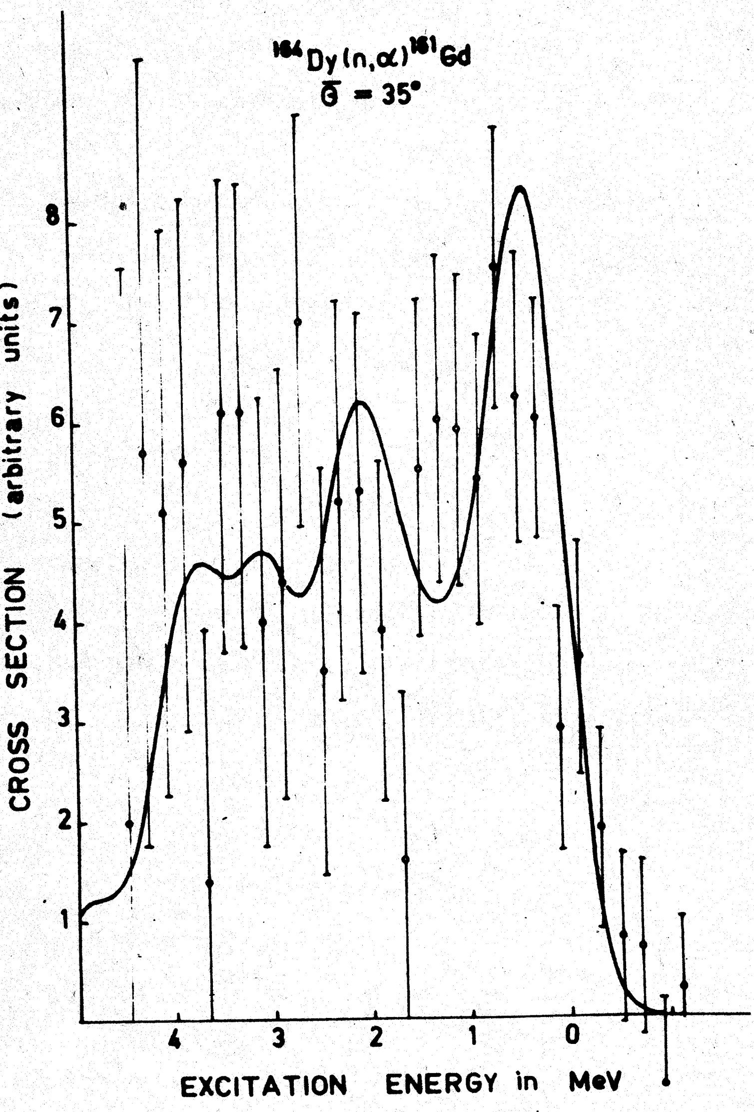
^{160}Dy(n,α)^{157}Gd
$\bar{\theta}$ = 35°
CROSS SECTION (arbitrary units)
9
8
7
6
5
4
3
2
1
5
4
3
2
1
0
EXCITATION ENERGY in MeV

fig. 1



$^{162}Dy\,(n,\alpha)^{159}Gd$
$\bar{\Theta} = 35°$
CROSS SECTION (arbitrary units)
1
2
3
4
5
6
7
8
4
3
2
1
0
EXCITATION ENERGY in MeV

fig.2



$^{164}Dy(n,\alpha)^{161}Gd$
$\bar{\Theta} = 35°$
CROSS SECTION (arbitrary units)
1
2
3
4
5
6
7
8
4
3
2
1
0
EXCITATION ENERGY in MeV

fig. 3

of sedimentation from suspensions in isopropyl alcohol.

The results of measurements are shown in figs.1-3. All spectra were measured for forward angles with average angle equal to 35°. The error bars in figures refer to statistical errors only.

In the figs. 1-3 the results of the calculations based on direct reaction mechanism [2] are also shown. In these calculations the knock-on mechanism was assumed.

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"Calculation of the energy spectra of alpha particles emitted during (n,α) reactions induced by 14 MeV neutrons in rare earth nuclei".

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It is now well established that the emission of α-particles under fast neutron bombardment in heavy nuclei ($A \gtrsim 120$) cannot be explained by means of the compound nucleus mechanism. In the last progress report [1] we have described a method of the energy spectra calculations based on direct reaction mechanism. In this model incident neutron knocks the alpha particle from the target nucleus and occupies the one-particle state in final nucleus. To describe this type of reaction the corresponding triangular graph of the disperssion theory [2] have to be calculated. We have shown that the experimental energy spectrum of α -particles from the $^{162}Dy(n,\alpha)^{159}Gd$ reaction at 14 MeV is in a good agree-

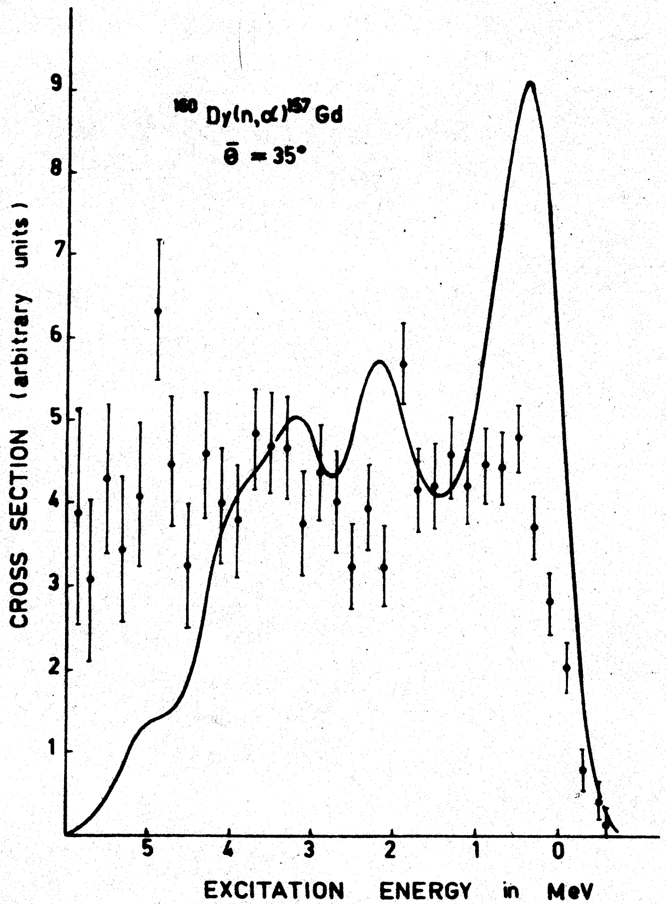

Fig.1 Comparison of the calculated relative cross section (full line) with experimental data for the ^{160}Dy(n,α)^{157}Gd reaction. The experimental resolution a is equal to 400 keV. The positions and the heights of the lines denote the energies and knock-on cross sections of single-neutron in the final nucleus. The asymptotic quantum numbers of Nilsson states are indicated above.

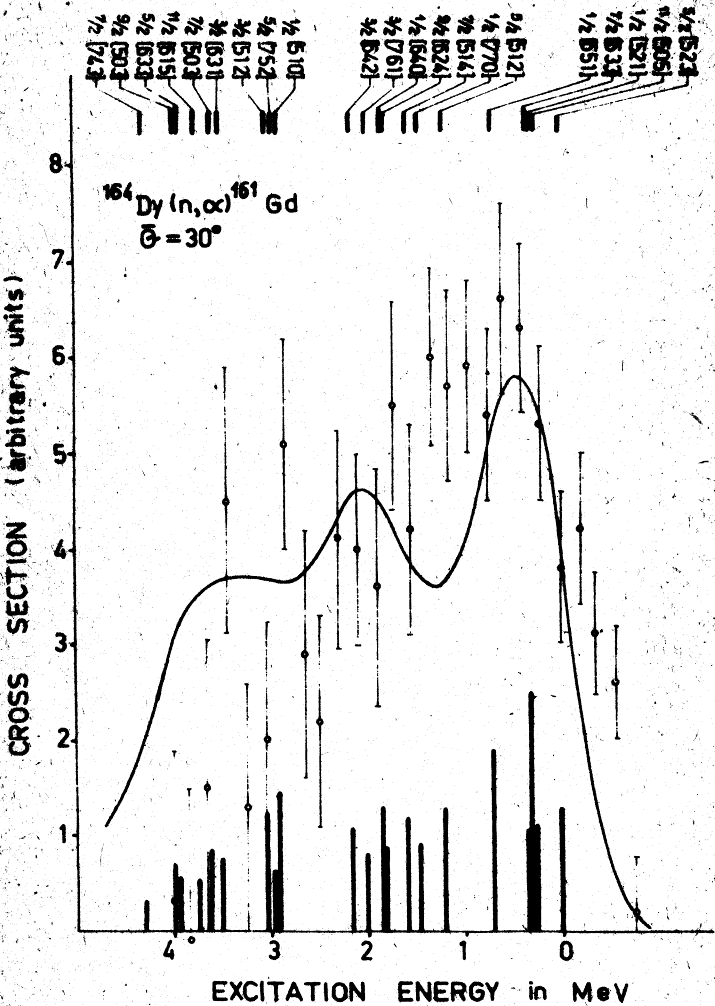

Fig.2 The $^{164}Dy(n,\alpha)^{161}Gd$ reaction. The experimental resolution a is equal to 380 keV. For other explanations see fig.1.

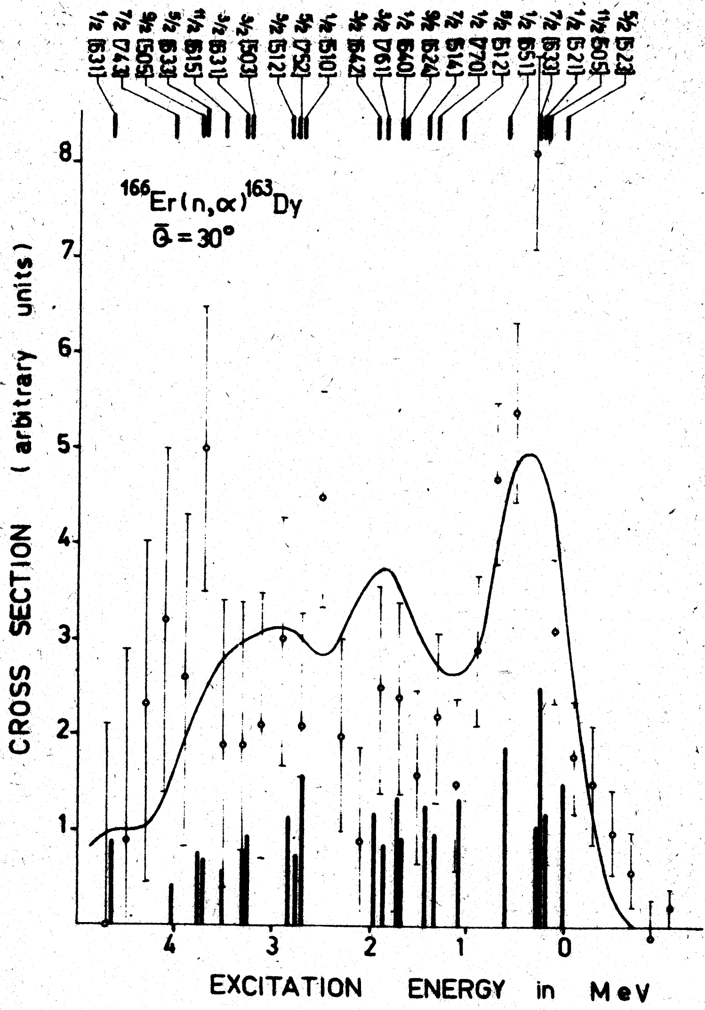

Fig.3 The $^{166}Er(n,\alpha)^{163}Dy$ reaction. The experimental resolution a is equal to 300 keV. For other explanations see fig.1.

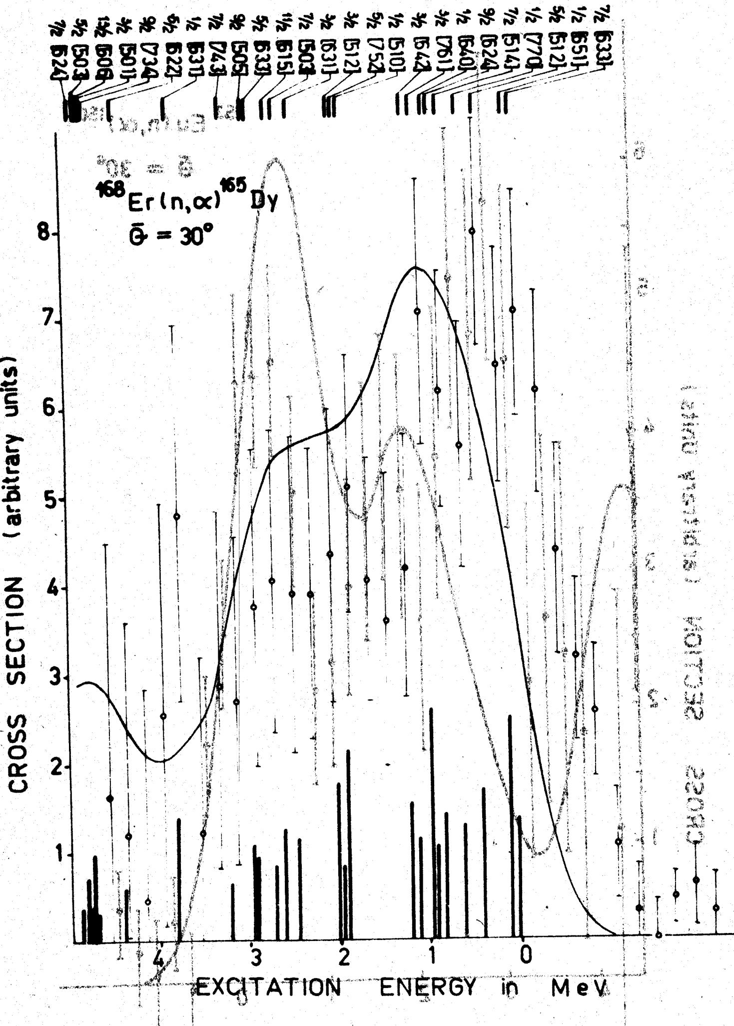

Fig.4 The ^{168}Er(n,α)^{165}Dy reaction. The experimental resolution a is equal to 400 keV. For other explanations see fig.1.

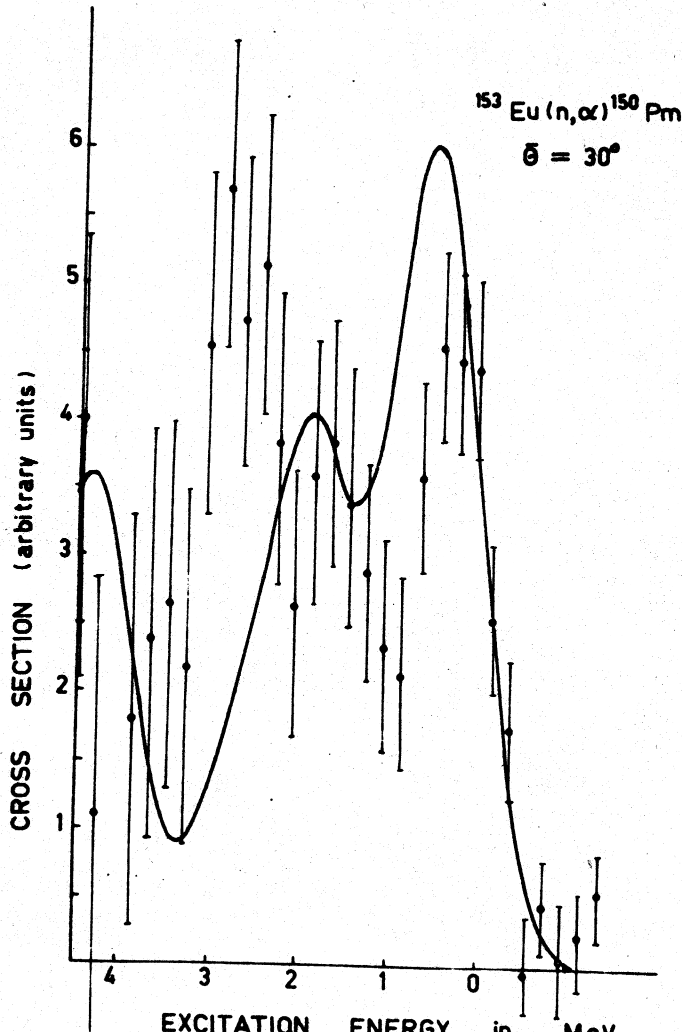

Fig.5. The ^{153}Eu(n,α)^{150}Pm reaction. The experimental resolution a is equal to 400 keV.

ment with the predictions of the model.

In this report we present the results of further calculations performed for $^{153}Eu(n,\alpha)^{150}Pm$, $^{160}Dy(n,\alpha)^{157}Gd$, $^{164}Dy(n,\alpha)^{161}Gd$, $^{166}Er(n,\alpha)^{163}Dy$ and $^{168}Er(n,\alpha)^{165}Dy$ at neutron energy equal 14 MeV. The calculated spectra are compared with the experimental data obtained in our laboratory [3] .

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The nature of "polar emission"

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Surprisingly high rate of α-particles going along the fission line [1] has been observed. According to our hypothesis this phenomenonis a manifestation of existence of others than the neutron and γ-ray deexcitation channels of the excited fission-fragments. The performed calculations show, that the experimental spectrum and intensity of alphas emitted along the heavy fragments-flight direction can be explained assuming the in-flight evaporation from these fragments if using the known from other sources data on excitation energy distribution, spin distribution, density of levels parameter, binding and pairing energies, mass and charge distributions in fission, moment of inertia optical model parameters etc. As concerns the alphas emitted in the same direction as the light fragments, their spectrum can be explained also , when taking into account the deformation of these fragments. However, for the interpretation of the intensity and of the angular distribution, rather unreasonable low value of the moment of inertia /~ 0.3 of $\mathcal{J}_{rigid}$/ should be assumed. The calculations for "polar" particles other then alphas were performed as well and, in particular an anticipated value of the ratio of $^{6}He/^{4}He$ intensities is by about 2 orders of magnitude smaller than in the tripartition of ^{236}U.

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"Investigation of the energy threshold of neutron registration in dielectric track detectors".

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In the Reactor Physics Department the dielectric track detectors are investigated, especially for the neutron fluence measurements. It is possible, among others, to detect neutrons by recording in polymer foil the tracks of recoil atoms, produced in elastic collisions of neutrons with the constituent atoms of detector. In order to establish the energy threshold and detection efficiency of neutron registration by recoil atom tracks the examined detectors (Makrofol E polycarbonate foils) have been irradiated with known fluences of monoenergetic neutrons.

The Van de Graaff accelerator "LECH" was used to obtain monoenergetic neutrons of 0.6 to 2.2 MeV energy from $T(p,n)^3He$ reaction. Thin tritium target was used. The neutron fluence was monitored with BF_3 "long" counter in all irradiations and moreover with fission track detectors for higher energy neutrons.

The irradiated foils were etched with 6.25 N NaCH or KOH water solutions at 60°C. The number and size of tracks is now examined under the microscope for particular neutron energy, etching solution and etching time. The results (series of curves) will enable to determine the energy threshold and efficiency of neutron registration as well as to optimize the etching conditions.

"Calibration of proportional counters used in neutron spectrometry ".

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A fast-neutron spectrometer has been developed in the Reactor Department for the investigation of reactor neutron spectra in fast multiplying media. The spectrometer consists of a spherical hydrogen-filled proportional counter 1 and an appropriate electronic system/ fast amplifier, n-gamma discriminating unit, two-dimensional analyzer etc./.

A series of spherical counters of various size and various hydrogen pressure has been constructed in the Nuclear Electronics Department of the INR. For each counter some instrumental spectra must be found for various energies of incident neutrons.

For this aim the Van de Graaff accelerator was used. Monoenergetic neutrons of 0.35 to 0.60 MeV energy range were obtained in a thin tritium target, using the $T(p,n)^3He$ reaction. The results of these calibrations were used after numerical processing in the unfolding of proton-recoil spectra, which are obtained in the counters placed in the neutron multiplying media.

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Energy levels of ^{228}Th excited in the decay of ^{228}Pa

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Abstract: The decay of ^{228}Pa has been studied by various techniques. Singles spectra of γ- and K X-rays have been measured with Si/Li/ and Ge/Li/ detectors. A set of two Ge/Li/ detectors has been used to study γ-γ and γ- K X-ray coincidences. Measurements of γ spectra in coincidence with selected internal -conversion lines have been carried out with a Ge/Li/ detector and a six-gap magnetic β spectrometer .

Finally, spectra of internal-conversion electrons have been studied in a β spectrometer which uses a Si/Li/ detector placed together with a system of diaphragms in a homogeneous magnetic field. The ^{228}Pa decay scheme has been constructed including 39 levels of ^{228}Th. It accounts for 111 of 160 transitions ascribed to the ^{228}Pa activity. The electron-capture decay energy has been determined to be $2103 {}^{+16}_{-12}$ keV. The strength distribution of the electron-capture feeding of the ^{228}Th levels is analysed in terms of current nuclear models.

The ^{228}Th levels below 1500 keV are grouped into 8 rotational bands. Four of these bands are believed to be related to the K = 0, 1, 2 and 3 octupole vibrations. Relative positions of the levels ascribed to the octupole bands can be reproduced rather well, provided that the theory takes into account the effect of Coriolis coupling. From the best-fit condition, the coupling matrix elements are found to be: A_{01} = 31.5 keV, A_{12} = 21.5 keV and A_{23} = 35.5 keV, while the unperturbed moment-of-inertia parameter, assumed the same for all octupole bands, is A_{o} = 8.34 keV. The values of coupling matrix elements are compared to the predictions of microscopic calculations. The paper is under preparation.