INDC(POL)-11/G

INSTYTUT BADAŃ JĄDROWYCH
ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ
INSTITUTE OF NUCLEAR RESEARCH

INR 1871/I/PL/A

PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES IN POLAND MAY 1979 - APRIL 1980

Compiled by
A.Marcinkowski

WARSZAWA 1980

W y d a j e Instytut Badań Jądrowych

Nakład 200 + 68egz. Objętość ark. wyd. 1,2 Ark. druk. 1,81
Data złożenia maszynopisu przez autora 2. VII. 1980 r.
Oddano do druku 28. VII. 1980 r. GP. II/441/1107/77 Zam. nr.

Editor's Note

This Progress Report on nuclear data research in Poland /May 1979 - April 1980/ contains only information on some research, related to the activities of the International Nuclear Data Committee of the International Atomic Energy Agency in the field of charged particles and neutron physics. It does not include any information about other nuclear research as for example 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 informacje o badaniach w zakresie fizyki jądrowej średnich energii przeprowadzonych w Polsce /maj 1979 - kwiecień 1980/ i związanych z działalnością Komitetu Danych Jądrowych Międzynarodowej Agencji Energii Atomowej.

Pominięto wyniki badań w innych dziedzinach fizyki jądrowej,w tym również badań 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 zgody autorów.

Замечания от редакции

Этот сборник содержит сообщения о проведенных в Польше в период от мая 1979 до апреля 1980 исследованиях в области физики средних энергии,связанных с деятельностью Комитета по Ядерным Данным Международного Агенства Атомной Энергии. Не включены результаты исследований с области применения нейтронов в физике твердого тела.Доклады не являются полными и не рекомендуется ссылаться на них без согласия авторов.

CONTENTS

THE REDUCED ALPHA WIDTH SYSTEMATICS IN THE RARE-EARTH REGION

W. Kusch

Institute of Nuclear Research, Dept. of Nuclear Reactions
Warsaw

The application of mass separators on accelerator beams made the spectroscopic investigations of isotopes far from stability line possible. A great number of new isotopes was identified recently, and a range of new data on neutron deficient alpha radioactive isotopes of rare-earth elements was obtained, what stimulated our attempt to complete and improve the alpha-decay systematics in this atomic number region.

Most experimental alpha-decay investigations in the rare-earth region were performed with great precision in the last decade by UNISOR [1-6] group. Recently the GSI group contributed remarkably to the complement of data [7]. The compilation published by Gauvin and al. [8] was used in our systematic as well.

Our investigation was based on experimental values of $W_\alpha = \lambda_{exp}/P$, primarily for the favoured transitions. The barrier penetrability P was calculated for the pure Coulomb barrier using Bethe formula [9] with the radius parameter $r_o = 1.55$ fm and then corrected using a function taking into account the Igo [10] dependence of the potential near the nuclear surface. The correction function was obtained by comparing the Rasmussen results [11] with those calculated by Bethe formula, using the same experimental data as starting point.

Estimation of all available experimental data in the rare-earth region led us to the conclusion that in most cases the accuracy of determination of the alpha particle energy E, the alpha branching ratio R and decay half life $T_{1/2}$ was sufficient for calculation of W_α with an error not larger than 30%. However, there is a certain number of results whose accuracy exceeds that limit. Thus the data for 8 transitions out of 49 analysed are not fully valuable. In several cases the confidence to the experimental results could be increased by an analysis based on the Geiger-Nuttal systematics.

The results of alpha reduced width calculations are presented in Table 1 and in Fig.1 and Fig.2. They are, in general, consistent with the fragmentary results given in published papers, as far as such calculations were performed.

The traditional presentation: $W_\alpha = f(N)$ for even Z elements (Fig.1) shows that the changes of W_α, generally moderate, do exhibit the odd-even effect. The Z dependence (Fig.2) is characterized by greater changes when passing from even to odd Z nuclei, it should be kept in mind, however, that some of the analysed alpha transitions were not identified unambiguously as the favoured ones.

For N=84 and even Z, W_α preserves an almost constant value in the investigated interval. We have plotted therefore the ratio log (W_N/W_{84}) for the remaining even Z isotopes in Fig. 3. A quite regular set of curves was obtained with minima at Z = 68 - 69, i.e. near the half of the filled $h_{11/2}$ proton shell.

Z \ N	84	85	86	87	88
60	3.65 (10)				
62	2.36 (5)	2.65 (10)	0.93 ● * 5.1 ■		
63	4.0 (12)				
64	1.95 (6)	1.11 (21)	3.69 (20) *	2.82 (20) *	2.99 (10) *
65	0.39 (27) 0.023 (12)	0.037 ● *	0.46 (17)		
66	2.68 (13)	1.46 (11)	3.17 (11)	2.07 (18)	2.3 ● *
67	1.41 (18) 0.26 (35)	0.92 (35) 0.70 (21)	3.07 (55) 0.79 (49)	<2.35 ●	
68	2.78 (8)	1.76 (11)	2.04 (40)	0.64 ● 1.83 ■	
69	1.93 (11)	1.48 (50) 1.89 (20)	<1.95 ● *	1.4 ■ *	
70	2.58 (10)	2.06 (26)	10.13 (33) 2.2 ■	1.58 ▲	1.72 ▲
71	2.12 (16)	1.42 (30) 1.54 (30)	1.52 (63)		
72	2.30 (35)	1.72 (13)	3.11 (12)	2.73 (17)	10.0 (34) *

Table 1. The reduced alpha widths in the rare-earth region, calculated according to the Bethe formula [9] and corected by the function accounting for the Igo dependence of the potential near the nuclear surface [10]. The full dots and squares - as in Fig.1, the asterisk denotes that the alpha particle energy has been measured with an error exceeding 10 keV and triangles indicate results based on estimations [12]. In paranthesis are errors in percent.

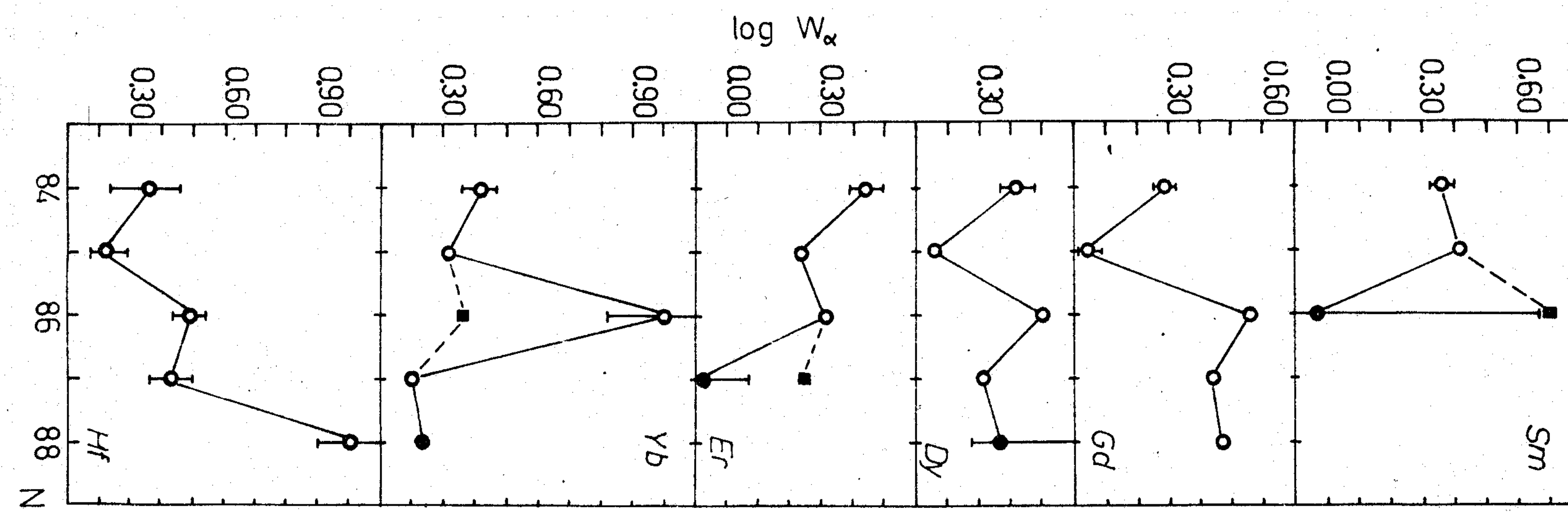


Fig.1. The dependence of log W_α on N for even Z nuclei in the interval $62 \leqslant Z \leqslant 72$. The full dots indicate data where the experimental error exceeds 30% and the squares denote transitions with alpha branching ratios estimated using Geiger-Nuttal systematics.

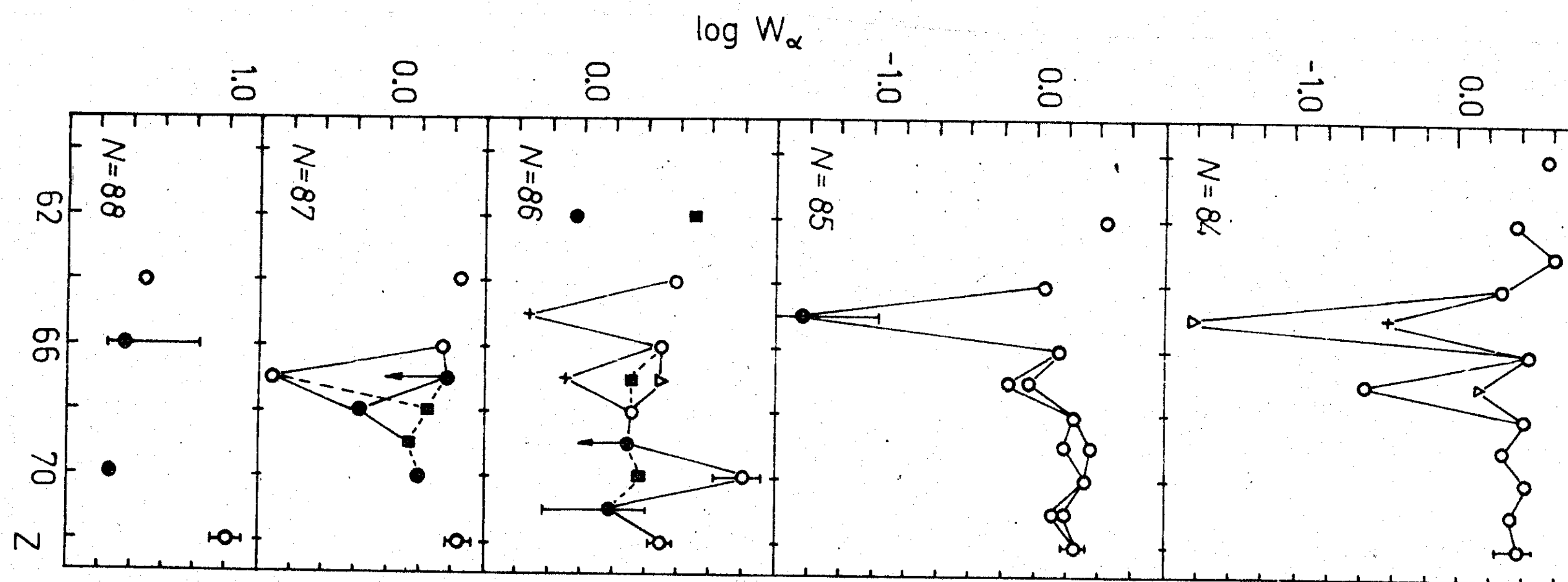


Fig.2. The dependence of log W_{α} on Z for N = 84 - 88. The full dots and squares - as on Fig.1, crosses denote $\Delta L > 0$ transitions, triangles show decays from the $1h_{11/2}$ states, arrows indicate that only upper limit of alpha branching ratio has been determined.

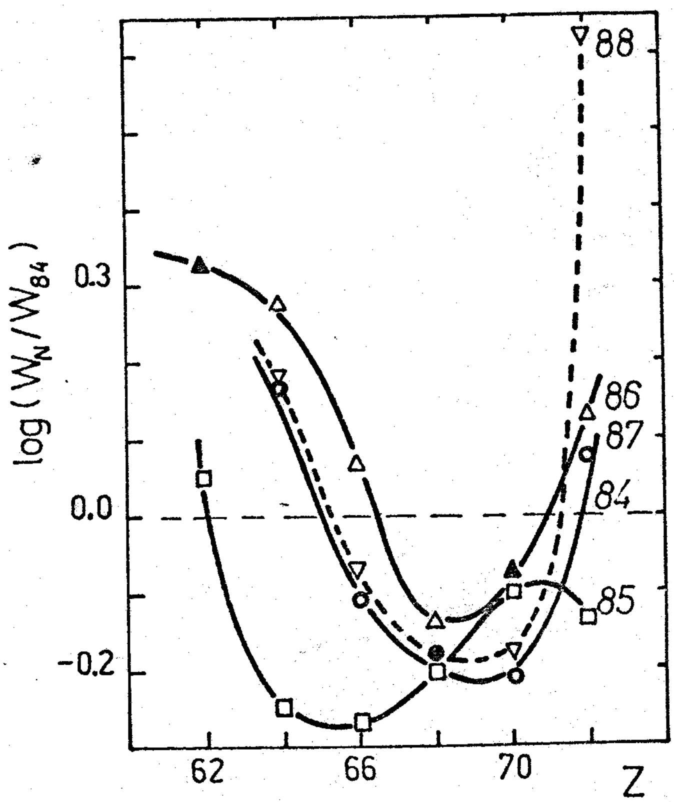


Fig.3. The dependence of log (W_N/W_{84}) on Z (even Z only).

REFERENCES

1. K.S. Toth, R.L.Hahn, M.A.Ijaz, Phys.Rev C4 (1971) 2223.
2. R.C.Bingham, D.U.O'Kain, K.S.Toth, R.L.Hahn, Phys.Rev C7 (1973) 2575.
3. W.D.Schmidt-Ott, K.S.Toth, E.Newman, R.C.Bingham, Phys. Rev. C10 (1974) 296.
4. K.S.Toth, R.C.Bingham, W.D.Schmidt-Ott, Phys.Rev. C10 (1974) 2550.
5. D.W.Schmidt-Ott, K.S.Toth, Phys.Rev. C13 (1976) 2574.
6. K.S.Toth, C.R.Bingham, H.K.Carter, G.B.Ritchi, D.C.Sousa, D.R.Zolnowski, Phys. Rev C20 (1979) 298.

7. S.Hofman, W.Faust, G.Münzenberg, W.Reisdorf, P.Armbruster, K.Güttner, H.Ewald, Z.Phys. A291 (1979) 53.

8. H.Gauvin, Y.Le Beyec, J.Livet, J.L.Reyss, Ann.Phys. 9 (1975) 241.

9. H.A.Bethe. Rev.Mod.Phys. 9 (1937) 69.

10. G.Igo, Phys.Rev. Lett. 1 (1958) 72.

11. J.O.Rasmussen, Phys.Rev. 113 (1959) 1953.

12. E.Hagberg, P.G.Hansen, J.C.Hardy, P.Hornshoj, B.Jonson, S.Mattsson, P.Tidemand-Petersson, Nucl.Phys. A293 (1977) 1.

ANGULAR DISTRIBUTIONS OF ALPHA PARTICLES FROM THE $^{143}Nd(n,\alpha_0)^{140}Ce$ REACTION INDUCED BY 14.1 AND 18.2 MeV NEUTRONS

W. Augustyniak, L. Głowacka, M. Jaskóła, Le Van Khoi*
J. Turkiewicz, L. Zemło
Institute of Nuclear Research, Dept. of Nuclear Reaction , Warsaw

Angular distributions of α -particles emitted in the $^{143}Nd(n,\alpha_0)^{140}Ce$ reaction at En = 14.1 and 18.2 MeV were measured by direct registration of α - particles using an n-type surface barrier silicon detector. The experimental arrangement used in the measurements was described in our earlier work [1] . The neutrons were obtained from the $^{3}H(d,n)^{4}He$ reaction with deuterons accelerated up to 2 MeV in the Van de Graaff accelerator "LECH". The neutron energy was selected by a suitable choice of the emission angle. The neutron energy spread due to the deuteron energy loss in the ^{3}H-Ti target and geometrical conditions were 120 and 140 keV for 14.1 and 18.2 neutrons, respectively. The neutron flux was measured by counting the recoil protons from a thin polyethylene foil. The recoil protons were registrated by a thin CsI(Tl) scintillator followed by photomultiplier and standard electronics. The absolute calibration of the neutron monitor was performed by measuring of the 847 keV γ -transition in ^{56}Fe produced in $^{56}Fe(n,p)^{56}Mn$ reaction with successive β-decay of ^{56}Mn. The cross sections for the $^{56}Fe(n,p)^{56}Mn$ reaction were taken as 110 mb and 57 mb for neutron energies 14.1 and 18.2 MeV, respectively [2] . Uncertainty of the monitor calibration amounts to about 15%.

---

*on leave from University of Hanoi, Vietnam

The investigated targets were made of neodymium oxide enriched with ^{143}Nd to about 88.4%. The Nd_2O_3 layers of about 3.0 mg/cm^2 were deposited onto a thick aluminium backings by the sedimentation technique.

The energy calibration of the alpha spectrometer was performed with employment of alphas from ThC and ThC′ and from the reaction $^{28}Si(n,\alpha)^{25}Mg$ produced in the silicon detector by the incident neutrons.

The angular distributions of α -particles emitted in the $^{143}Nd(n,\alpha_o)^{140}Ce$ reaction at 14.1 and 18.2 MeV neutrons are listed in tables 1 and 2 and also presented in Fig.1. The data are given in laboratory system. These distributions contain all α -particles with energies corresponding to the ground state transition of the final nucleus ^{140}Ce. In the bottom of the tables the angular spreads of the measurements are also shown. These spreads were calculated by Monte-Carlo method [3] . The errors indicated in the tables are only statistical.

REFERENCES

1. M.Jaskóła, J.Turkiewicz, L.Zemło, W.Osakiewicz, Acta Phys. Pol., B2 (1971) 521
2. D.C. Santry, J.Butler, Can. J.Phys., 42 (1964) 1030
3. L.Zemło, INR Report, 1464/I/PL/B (1973)

TABLE I

Angular distribution of α -particles for $^{143}Nd(n,\alpha_o)^{140}Ce$ reaction at E_n = 14.1 MeV

θ_{lab} [deg]	$d\sigma/d\Omega$ [mb/sr]
26	0.078 ± 0.007
46	0.068 ± 0.011
63	0.039 ± 0.009
90	0.003 ± 0.002
117	0.006 ± 0.004
135	−0.003 ± 0.010
156	0.001 ± 0.002

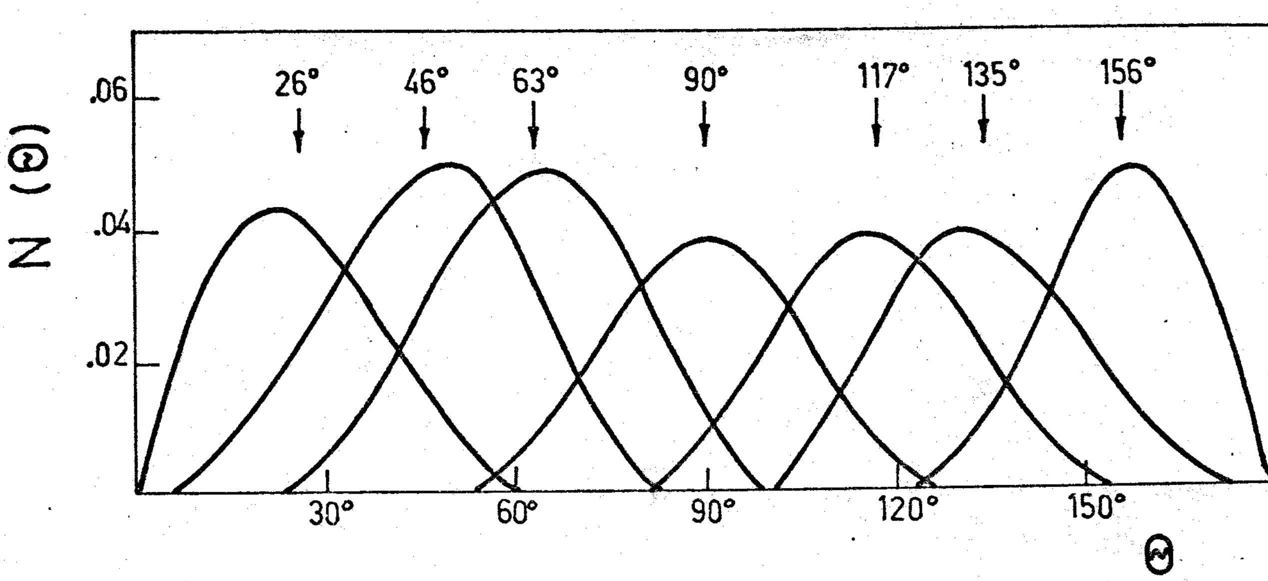
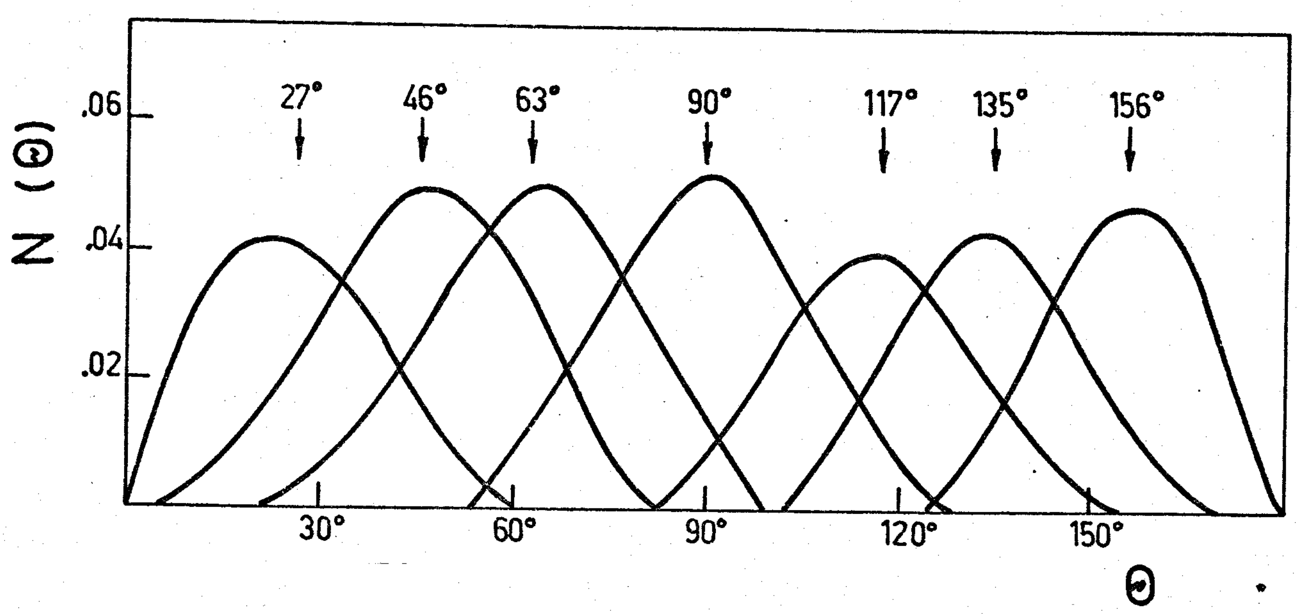


TABLE II

Angular distribution of α -particles for $^{143}Nd(n,\alpha_0)^{140}Ce$ reaction at E_n - 18.2 MeV

Θ_{lab} [deg]	$d\sigma/d\Omega$ [mb/sr]
27	0.110 ± 0.008
46	0.037 ± 0.010
63	0.030 ± 0.010
90	0.012 ± 0.012
117	0.005 ± 0.025
135	0.014 ± 0.018
156	0.026 ± 0.009



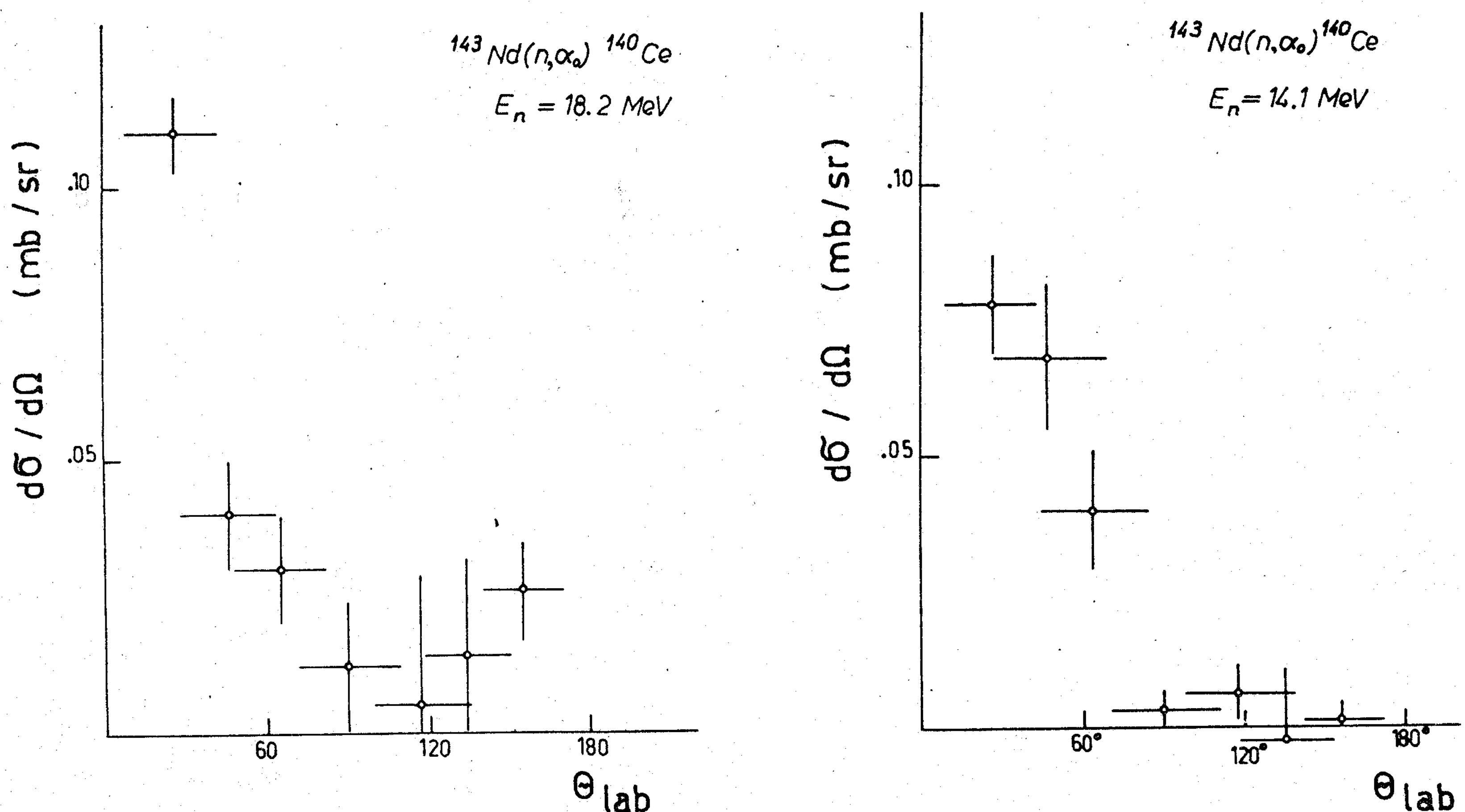


Fig.1. The angular distributions of α-particles leading to the ground state residual nucleus ^{140}Ce.

CROSS SECTIONS FOR THE FAST NEUTRON INDUCED REACTIONS ON Si AND Zn ISOTOPES

M. Herman and A. Marcinkowski
Institute of Nuclear Research, Warsaw

and

J. Dresler and U. Garuska
Institute of Physics University, of Łódź

The cross sections for the $^{28}Si(n,p)^{28}Al$, $^{29}Si(n,p)^{29}Al$, $^{30}Si(n,\alpha)^{27}Mg$, $^{68}Zn(n,\alpha)^{65}Ni$ and $^{70}Zn(n,2n)^{69m}Zn$ reactions were measured by the activation method in the neutron energy range from 13 to 17 MeV. Natural, high-purity Si and Zn samples were activated in the neutron beams obtained from the $^{3}H(d,n)^{4}He$ reaction. Tritium absorbed in a Ti foil was bombarded with deuterons accelerated in a 3 MeV Van de Graaff accelerator. In order to obtain the absolute neutron flux, use was made of the $^{56}Fe(n,p)^{56}Mn$ monitoring reaction [1]. The cross sections measured in the present experiment are summarized in Table 1. The neutron energy spread was obtained by calculating the effective energy distributions of neutrons incident on the samples by means of the Monte Carlo code LOS [2]. The indicated errors of the cross sections include the statistical errors.

REFERENCES

1. D.C. Santry and J.P. Butler, Can. J. Phys. 42 (1964) 1030
2. L. Zemło, Institute of Nuclear Research report INR-1464.

Neutron energy MeV	Experimental cross sections (mb) $^{28}Si(n,p)^{28}Al$	$^{29}Si(n,p)^{29}Al$ *	$^{30}Si(n,\alpha)^{27}Mg$
13.0 ± 0.4	328 ± 24	117 ± 30	79 ± 17
13.4 ± 0.2	265 ± 17	117 ± 11	113 ± 10
13.9 ± 0.3	285 ± 19	134 ± 15	118 ± 11
14.5 ± 0.3	242 ± 16	129 ± 13	110 ± 9
15.0 ± 0.3	219 ± 14	137 ± 13	110 ± 9
15.4 ± 0.2	196 ± 16	131 ± 14	111 ± 10
15.9 ± 0.5	231 ± 18	143 ± 32	102 ± 20
16.6 ± 0.1	195 ± 16	125 ± 31	117 ± 20
17.4 ± 0.4	171 ± 15	143 ± 29	86 ± 21
17.9 ± 0.1	154 ± 13	144 ± 28	123 ± 24

	$^{68}Zn(n,\alpha)^{65}Ni$	$^{70}Zn(n,2n)^{69m}Zn$
13.0 ± 0.4	10 ± 2	502 ± 40
13.4 ± 0.2	10 ± 1	460 ± 29
13.9 ± 0.3	7 ± 1	442 ± 28
14.5 ± 0.3	8 ± 1	448 ± 29
15.0 ± 0.3	8 ± 1	475 ± 31
15.4 ± 0.2	8 ± 1	463 ± 30
15.9 ± 0.5	8 ± 2	565 ± 45
16.6 ± 0.1	6 ± 1	501 ± 42
17.4 ± 0.4	6 ± 2	583 ± 49
17.9 ± 0.1	5 ± 1	575 ± 47

* measured cross section of the $^{29}Si(n,p)^{29}Al$ reaction plus 0.67 times the cross sections of the $^{30}Si(n,pn)^{29}Al$ and $^{30}Si(n,np)^{29}Al$ reactions.

CROSS-SECTION MEASUREMENTS OF THE (n,α) REACTION AT E_n = 14.6 MeV

U.Garuska, J.Dresler and H.Małecki
Institute of Physics University of Łódź

At the Institute of Physics of the University of Łódź, we have been investigating the nuclear reaction induced by the 14.6 MeV neutrons on ^{41}K, ^{45}Sc, ^{63}Cu, ^{68}Zn, ^{79}Br, ^{81}Br and ^{92}Mo. The neutrons were obtained from the $^{3}H(d,n)\alpha$ reaction on the electrostatic cascade accelerator. The neutron flux was $5 \cdot 10^{9}$ neutrons/s. Samples of pure elements, both natural and highly isotopic were used. The neutron flux was determined by using $^{56}Fe(n,p)^{56}Mn$ as the reference reaction. We accepted the cross-section for this reaction as 105 ± 4 mb [1]. The cross-sections measured are listed in Table 1.

TABLE I

Isotope	Cross-section (mb)
^{41}K	30 ± 3
^{45}Sc	71 ± 9
^{63}Cu	43 ± 2
^{68}Zn	10 ± 1
^{79}Br	16 ± 5
^{81}Br	12 ± 5
^{92}Mo	24 ± 3

The errors given in Table 1 include the errors of sample weight, errors due to the efficiency of the detector, statistical errors and the error of cross-section of reference reaction.

REFERENCES

1. M.D.Goldberg et al. BNL 325, 1966.

THE ENERGY DEPENDENCE FOR THE FUSION CROSS SECTIONS FOR ^{6}Li, ^{9}Be AND ^{12}C IONS INTERACTING WITH ^{28}Si NUCLEI

K.Bodek, L.Jarczyk, B.Kamys, A.Magiera, A. Strzałkowski, G. Willim
Institute of Physics, Jagellonian University, 30059 Cracov, Poland

K.Jankowski, W.Zipper
Institute of Physics, Silesian University, Katowice, Poland

M.Hugi, J.Lang, R.Müller, E.Ungricht
Laboratorium für Kernphysik, Eidg.Technische Hochschule, 8093 Zürich, Switzerland

The angular distributions of the evaporation spectra of protons, deuterons and alpha particles have been measured for $^{6}Li+^{28}Si$ system at the laboratory energies 13, 20, 25 MeV, for $^{9}Be+^{28}Si$ system - at 12, 14, 17, 20, 23, 30 MeV, and for $^{12}C+^{28}Si$ system - at energies 22, 27, 36 MeV. Experiment was performed at the ETH tandem Van de Graaff accelerator in Zürich. The measurements of the angular distributions were performed in the angular range from 40^{o} up to 160^{o} in 20^{o} steps in the lab. system. Experimental energy spectra, angular distributions and integrated over backward angle range were compared with predictions of the statistical model. The fusion cut-off angular momenta and fusion cross sections were deduced from such analysis. Theoretical calculations were performed using GROGI-2 and EVAN codes. Obtained in this way fusion cross sections were compared with those estimated from the interaction barrier using the real part of the optical model potential.

NUCLEAR REACTIONS IN THE $^{13}C + ^{9}Be$ SYSTEM AT C.M.ENERGY OF ABOUT 11.6 MeV

K.Bodek, L.Jarczyk, B.Kamys, M.Porębska, J. Sromicki, A.Strzałkowski
Institute of Physics, Jagellonian University, 30059 Cracow, Poland

M.Hugi, J.Lang, R.Müller, E.Ungricht
Laboratorium für Kernphysik, Eidg. Technische Hochschule, 8093 Zürich, Switzerland

The angular distributions of protons, deuterons, tritions, alpha particles nad ^{8}Be have been measured for the $^{13}C + ^{9}Be$ system at the c.m. energy around 11.6 MeV. Experiment was performed at the ETH tandem Van de Graaff accelerator in Zürich. The measurements of the angular distributions were performed in the angular range from 10^{o} up to 125^{o} in 5^{o} steps in the lab. system. The results concerning the light particle emission have been analysed by compound nucleus model, those for ^{8}Be in the DWBA approximation. It was found that for alpha particle channel there exist the contribution from the other processes not predicted by the statistical model. The obtained results indicate a very close similarity of reaction mechanisms for the two $^{13}C + ^{9}Be$ and $12C + ^{9}Be$ systems.

ELASTIC AND INELASTIC SCATTERING OF ^{9}Be ON ^{10}B TARGET AT ENERGIES $E_{c.m.}$ = 10.5 MeV AND 15.8 MeV

K.Bodek, M.Godlewski, L.Jarczyk, A.Strzałkowski
Institute of Physics, Jagellonian University 30059 Cracow, Poland

M.Hugi, J.Lang, R.Müller, A.Schiltz, E.Ungricht
Laboratorium für Kernphysik, Eidg. Technische Hochschule
8093 Zürich, Switzerland

Angular distributions of ^{9}Be scattered on ^{10}B nuclei have been measured at c.m. energies 10.5 MeV and 15.8 MeV. In the present experiment the ^{9}Be beam from the ETH tandem accelerator was used. The measurements of the angular distributions were performed from 21° to 170° and from ~70° to ~ 170° for ground state and excited states of ^{10}B /0.72 MeV, 1.74 MeV, 2.15 MeV, 3.59 MeV/ respectively. Experimental angular distributions show backward increase of cross sections. Elastic scattering data were analyzed by use of optical model potential. The failure of the optical model to explain the backward increase of the cross sections was removed to some extend by adding the proton elastic transfer.

Inelastic scattering data /at backward angles/ were compared with theoretical ones obtained from Mars-Saturn DWBA code for particle transfer.

NEURTON TRANSFER REACTIONS on ^{9}Be, ^{12}C, ^{13}C, ^{28}Si AND ^{40}Ca NUCLEI INDUCED BY ^{9}Be BEAM

L.Jarczyk, B.Kamys, A.Strzałkowski, Z.Wróbel
Institute of Physics, Jagellonian University, Cracow, Poland

M.Hugi, J.Lang, R.Müller, E.Ungricht
Laboratorium für Kernphysik, Eidg. Technische Hochschule Zürich, Switzerland

Angular distributions of ^{8}Be-ions for well separated states of the residual nuclei at beam energy of ^{9}Be equal 20 MeV /lab/ have been measured for the ^{9}Be, ^{12}C, ^{13}C and ^{40}Ca as a target. For the ^{28}Si-target the measurement has been carried out at the energies 14, 20, 26 and 30 MeV /lab./. The ^{9}Be-beam was produced at the ETH tandem Van de Graaff accelerator in Zürich. For the ^{9}Be-target the angular distributions of ^{8}Be-ions are symetric around 90° in the c.m. system, in the case of carbon targets pronounced enhancements of the cross-sections were observed at backward angles. For ^{28}Si and ^{40}Ca targets the angular distributions are peaked at the forward angles.

DWBA calculations were applied to describe the angular distributions for all observed excited states using computer-code MARS-SATURN. The angular distributions are very well reproduced by the calculations. This allows to estimate the neutron spectroscopic factor of ^{9}Be. For ^{12}C and ^{13}C target nuclei the additional transfer of ^{4}He or ^{5}He must be included to the calculations to reproduce the behaviour of the cross-sections in the full angular range. For ^{9}Be-target the existence of the identical particles in the incoming channel was taken into account. The neutron-transfer together with compound contribution, calculated according to the Hauser-Feshbach model, do not reproduce very well the angular distributions, in that case.

ENERGY DEPENDENCE OF REACTIONS IN THE $^{9}Be + {}^{12}C$ SYSTEM

K.Bodek, L.Jarczyk, B.Kamys, J. Sromicki, A. Strzałkowski, H. Witała
Institute of Physics, Jagellonian University, 30059 Cracow, Poland

M.Hugi, J.Lang, R.Müller, E.Ungricht
Laboratorium für Kernphysik, Eidg. Techn. Hochschule,
8093 Zürich, Switzerland

Excitation curves for $^{9}Be + {}^{12}C$ induced reactions with emission of protons, deuterons, tritions α-particles, ^{8}Be and ^{12}C ions have been measured at some fixed lab. angles in the energy range from 5.85 to 15.43 MeV, c.m. in energy steps of 107 keV.

For light particle emission in the backward hemisphere, where a ^{9}Be target and a ^{12}C beam were used, the measurements were performed at 5^{o}, 10^{o}, 20^{o} and 30^{o} lab. angles, for emission in the forward direction, where the roles of target and beam particles were interchanged, at the 14.6^{o}, 24.6^{o}, 44.6^{o} and 54.6^{o} lab. angles. Excitation functions for emission of ^{8}Be ions were measured at 7.5^{o}, 27.5^{o} and 47.5^{o} lab. angles with ^{12}C beam and for emission of ^{12}C ions at 170.0^{o}, 160.0^{o}, 140.0^{o}, $120.^{o}$ and 35.2^{o} c.m. angles with ^{9}Be beam.

The absolute values of the cross sections were obtained from comparison with the cross sections for elastic scattering measured simultaneously.

For proton, deuteron and triton outgoing channels average cross sections agree well with the Hauser-Feshbach predictions. In excitation curves for α-particles, ^{8}Be and ^{12}C outgoing channels strong structures could be noticed. In search for some correlated structure a statistical analysis of excitation curves has been done.

INVESTIGATION OF NUCLEON-UNBOUND STATES IN ^{29}Si, ^{29}P, ^{25}Mg AND ^{25}Al NUCLEI BY THE REACTIONS $^{28}Si(d,pn)$ AND $^{24}Mg(d,pn)$.

K.Bodek, L.Jarczyk, B.Kamys, K.Seliger, Z.Wróbel
Institute of Physics, Jagellonian University, Cracow, Poland

J.Lang, R.Müller, C.M.Teodorescu, J.Unternährer
Laboratorium für Kernphysik, Eidg.Techn.Hochschule
Zürich, Switzerland

Deuteron stripping reactions leading to unbound states were investigated by measuring proton-neutron correlations. Triple differential cross-sections $d^3\sigma/d\Omega_p\, d\Omega_n\, dE$ were measured in the angular range from 15° to 165° in steps of 15°. The experiment was carried out at the ETH tandem Van de Graaff accelerator in Zürich.

In the case of $^{24}Mg(d,pn)$ reaction the study has been carried out at $E_{lab.}$ = 10.5 MeV. Twenty-six states of ^{25}Mg were observed in the energy range from 8.1 to 11.6 MeV and 29 states of ^{25}Al in the energy range from 4.6 to 9.2 MeV.

In the case of $^{28}Si(d,pn)$ reaction the study has been carried out at $E_{lab.}$ = 11.0 MeV. Twenty-three states of ^{29}Si were observed in the excitation energy range from 9.00 MeV to 13.43 MeV and 17 states of ^{29}P in the energy range from 5.48 to 9.81 MeV.

For most of the excited states spin, parity, widths and decay modes were derived. A spin of $5/2^+$ for the ground state of ^{25}Si was deduced.

THE ENERGY DEPENDENCE OF FUSION AND REACTION CROSS SECTIONS IN THE ^{9}Be + ^{12}C SYSTEM

K.Bodek, L.Jarczyk, B.Kamys, A. Magiera, J. Sromicki
A. Strzałkowski, G.Willim, Z.Wróbel
Institute of Physics, Jagellonian University, 30059 Cracow, Poland

D.Balzer, M.Hugi, R.Müller, E.Ungricht
Laboratorium für Kernphysik, Eidg.Technische Hochschule,
8093 Zürich, Switzerland

Angular and energy distributions of protons, deuterons, tritions and alpha particles have been measured for ^{9}Be + ^{12}C system at the lab. energies 12, 14, 17, 20, 23, 23.5 and 27 MeV. The ^{9}Be beam was produced at the ETH tandem Van de Graaff accelerator. The measurements of the angular distributions were performed in the angular range from 15^{o} up to 165^{o} in 5^{o} steps in the lab. system. The fusion cut-off angular momenta and fusion cross sections were estimated from the analysis of proton, deuteron and triton data by performing the Hauser-Feshbach calculations. The energy dependence of the fusion cross sections was established and compared with the reaction and fusion cross sections calculated with the optical model, reproducing elastic scattering data.
The behaviour of the alpha particle distributions cannot be explained by the compound nucleus process only, but indicates contributions from other processes. The latter was analysed in the DWBA model assuming a direct transfer reaction mechanism.

THE NUCLEAR REACTIONS IN THE $^{9}Be+^{9}Be$ SYSTEM AT C.M. ENERGY 7 MeV

K.Bodek, L.Jarczyk, B.Kamys, A.Magiera, J.Sromicki
A.Strzałkowski
Institute of Physics, Jagellonian University, 30059 Cracow, Poland

M.Hugi, J.Lang, R.Müller, E.Ungricht
Laboratorium für Kernphysik, Eidg. Technische Hochschule
8093 Zürich, Switzerland

The angular distributions of protons, deuterons, tritons, alpha particles and ^{7}Li nuclei have been measured for $^{9}Be + {}^{9}Be$ system at the c.m. energy 7 MeV. Experiment was performed with the ^{9}Be beam from the ETH tandem Van de Graaff accelerator. The angular distributions have been measured for Lab. angles 15^{o}-85^{o} in 5^{o} steps, and for 100^{o}, 120^{o}, 140^{o}. It was found that the formation of the compound system is the dominant process in the proton, deuteron and triton channels, and that for the alpha particle and ^{7}Li exit channels the transfer processes are possible. The fusion cut-off angular momentum and fusion cross section have been determined from the performed analysis.