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PROGRESS REPORT

HUNGARY

1972

INSTITUTE OF EXPERIMENTAL PHYSICS,

KOSSUTH UNIVERSITY

DEBRECEN

NUCLEAR DATA PROGRAM AT THE INSTITUTE OF EXPERIMENTAL PHYSICS, KOSSUTH UNIVERSITY, DEBRECEN

Though the main purpose of this Institute is physics education, there is a considerable activity in the field of fast neutron physics. In addition to the experimental measurement of neutron data, some evaluation work is in development, too.

EXPERIMENTAL FACILITIES

1./ 800 kV /40 μA/ Open-air type Van de Graaff generator;

2./ 200 kV /2 mA/ neutron generator /home made/;

3./ 180 kV /1.2 mA/ Activatron-111 neutron generator /IAEA/;

4./ Associated-particle system for ^{3}He and ^{4}He; this can be mounted onto any of the neutron generators;

5./ Pneumatic transport system for quick automatic sample transfer;

6./ Pu-Be neutron sources from 0.5 Ci to 5 Ci;

7./ 25 cm^3 Ge-Li detector with cryostat /IAEA/;

8./ 4000 channel DIDAC /Intertechnique/ analyser; three 100 - channel analysers;

9./ Tally tape perforator /IAEA/, printer, tape-reader, X-Y plotter, spectrum-stabilizer;

10./ Lorenz telex with tape-punching and punched tape reading units in five-hole CCIT code /Hungarian Atomic Energy Committee/;

11./ ^{6}LiJ /Eu/ crystal /IAEA/ spectrometer;

12./ ^{3}He proportional counter;

13./ Low-background proportional counter for the measurement of weak beta and/or gamma rays, e.g. tritium, with a sensitivity of a few pCi;

CROSS SECTIONS FOR THE $^{113}In/n,n'\gamma/^{113}In$ AND $^{103}Rh/n,n'\gamma/^{103m}Rh$ REACTIONS

/n,n'γ/ cross sections leading to metastable states have been measured for ^{113}In at 2.8 MeV and 14.7 MeV as well as for ^{103}Rh at 14.7 MeV neutron energies; the results are 260 ± 25 mb, 66 ± mb and 289 ± 25 mb, respectively. The conversion coefficient has been deduced for the decay of ^{103m}Rh: $\alpha_K = 123 \pm 14$.

INVESTIGATION /n,t/ CROSS SECTIONS FOR 14 MeV NEUTRONS

Using a low-background proportional counter /see item 13. of facilities/ measurements of /n,t/ cross sections are in progress for $A < 100$ nuclei. The irradiated samples are outgassed in a special heating system, and the tritium gas produced lead into the proportional counter. In order to avoid the background an electronic pulse shape discrimination system has been developed; this proved to be more effective than the conventional anti-coincidence shielding. This means that the investigations can be extended to low /n,t/ cross sections, i.e. to targets with higher mass numbers. At present /n,t/ cross sections were measured for Be, B, Fe, Ni, and Cu at 14.7 MeV neutron energy.

^{238}U FISSION YIELD MEASUREMENTS WITH Ge/Li/ DETECTOR FOR 14 MeV NEUTRONS

In order to study the yield of fragments from a fission process with low cross section, the direct measurement of gamma-spectra of thick samples irradiated by 14 MeV neutrons was undertaken, without any chemical separation or application of recoil effects. For neutron induced fission of ^{238}U the cumulative yields /relative to that of ^{140}Ba/ of ten isotopes were determined using a Ge/Li/ detector and a thick uranium target.

AVERAGE CROSS SECTIONS FOR Pu - ALFA - Be NEUTRONS: LOW ENERGY NEUTRONS FROM ALFA-N SOURCES

Average activation cross sections for a number of elements were determined using unmoderated neutrons from Pu--Be and Po-Be sources. Applying threshold detectors it was found that 10% of Pu-Be neutrons is emitted in the energy intervals from 10 keV to 100 keV. Neutron spectra from $PuBe_{13}$ sources of different dimensions are the same within the interval 0.5 Ci and 5 Ci; the majority of neutrons below 2 MeV come from the multibody break up of ^{13}C.

EVALUATION OF /n,2n/ CROSS SECTIONS AT 14.7 MeV

On the basis of experimental data and N-Z systematics most probable /n,2n/ cross section values were calculated for isotopes and elements. The present cross sections were compared with those given by empirical formulas.

DESCRIPTION OF FAST NEUTRON CROSS SECTIONS BY A SEMICLASSICAL MODEL

The applicability of a simple, semi-classical optical model to the description of nonelastic and integrated elastic neutron cross sections was investigated at 14 MeV, and found to be justified. Using the nonelastic cross sections, nuclear radius parameters were determined; their magnitude and A-dependence is close to that of the electromagnetic r_o-values.

PLANS FOR THE FUTURE

Practically all of the above-mentioned topics will be continued in the next year;

/n,t/ cross section measurements to higher A-values; cross section measurements on fuel and structural materials using ^{252}Cf neutron source /fission spectrum/; investigations on the mass and charge distribution of fission fragments;

neutron diffusion and cooling in moderators; low-energy charged particle cross section measurements with fusion and astrophysical interest;

compilation and evaluation work to find best values of several measurements, simple empirical expressions describing microscopic cross sections, search for systematics.

INSTITUTE OF NUCLEAR RESEARCH

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DEBRECEN

L-SUBSHELL, M- AND N- SHELL INTERNAL CONVERSION RATIOS THE 391,7 keV ISOMERIC TRANSITION OF ^{113}In

A. Kövér, D. Berényi, J. Csongor[x]

In press in Zeitschrift für Physik

The L_I, L_{II} and L_{III} as well as the M and N internal conversion lines from the 391,7 keV 100 min isomeric transition of ^{113}In have been studied and the ratios of the conversion coefficients determined in a special permanent magnet beta-ray spectrograph of 75 cm maximum radius.[1] The multipolarity of the transition have been stated to be M4 comparing the obtained $L_I/L_{II} = 6,7 \pm 1,3$ and $L_I/L_{III} = 4,9 \pm 0,8$ ratios with the theoretical calculations [2-4]. The possible maximum E5 admixture on the basis of our experimental data has been calculated by a computer program[5]. The L/M as well as the L/N and M/N ratios show a good agreement with the corresponding theoretical values including the recent results of the calculations for the N shell[6].

1. J.Schadek, D. Berényi and F. Illés, Atomki Közlemények 3 /1961/ 105
2. M.E.Rose, "Internal Conversion Coefficients." North-Holland Publ. Co., Amsterdam, 1958.
3. L.A.Sliv's and I.M. Band's values from K.Siegbahn, "Alpha-, Beta- and Gamma-Ray Spectroscopy, Vol.2. North-Holland Publ. Co. Amsterdam, 1965.
4. R.S.Hager and E.C.Seltzer, Nuclear Data 4A /1968/ 1.
5. H.J.Hennecke, J.C.Manthuruthil and O.Bergman, and C.R.Cothern, Phys.Rev. 159 /1967/ 955
6. O.Dragoun, Z.Plajner and F.Schmutzler, Nuclear Data A9 /1971/ 119

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THE $^{23}Na/d,p/^{24}Na$ REACTION AT DEUTERON ENERGIES 670 AND 620 keV

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To be published in Acta Physica Acad. Scient. Hungaricae

The angular distributions and absolute cross-sections of proton groups p_o,p_1,p_2,p_3+p_4 and p_5+p_6 from the reaction $^{23}Na/d,p/^{24}Na$ have been measured at E_d = 670 and 620 keV. Deuterons were accelerated by the cascade generator of ATOMKI, Institute of Nuclear Research, Debrecen, Hungary and protons were detected by a semiconductor detector. The angular distributions were obtained asymmetrical about 90°. The total cross-section data, listed in Table I, have the errors in general about 25 %.

Table I.

Energy /keV/	Cross-section of groups /μb/				
	p_o	p_1	p_2	p_3+p_4	p_5+p_6
670	27	24	30	113	70
620	18	8.5	13	47	19

The experimental data have been analysed in terms of Legendre polynomials and DWBA method, used optical potential parameters from [1,2]. The DWBA calculations reproduced the angular distributions of proton groups p_3+p_4 and p_5+p_6, while it did not give good results in the case of p_o,p_1 and p_2. The analysis of our experimental results suggests, that at low bombarding energies in this reaction both the compound nucleus and the direct interaction mechanism simultaneously exist, and in the case of p_3+p_4 and p_5+p_6 the contribution of the direct interaction is predominant.

Our results are in agreement with the conclusions given by El-Behay et al. [3].

1. F.G.Perey, Phys.Rev., 131, 745, 1963.
2. A.Gallmann et al. Nucl.Phys., 88, 654, 1966.
3. A.Z.El-Behay et al., Nucl.Phys., 74, 225, 1965.

INVESTIGATION OF THE $^{14}N/d,p/^{15}N$ AND $^{14}N/d,\alpha/^{12}C$ REACTIONS BELOW THE COULOMB BARRIER

I. Hunyadi, L. Meskó, B. Schlenk, A. Valek and M.H.S.Bakr[x]

To be published in Acta Physica Acad.Scient.Hungaricae

The study of $^{14}N/d,p/^{15}N$ and $^{14}N/d,\alpha/^{12}C$ nuclear reactions is in progress at the cascade generator of ATOMKI, Institute of Nuclear Research, Debrecen, Hungary. The angular distributions of p_o,p_1+p_2,p_3+p_4,p_5 and α_o, α_1 groups were measured by semiconductor detector at E_d = 626, 576, 475, 374 and 324 keV energies on thin adenine target. The excitation functions of the above mentioned groups were measured at 90° in the energy range E_d = 310 - 640 keV using gaseous target method. The obtained differential cross-sections varied smoothly with the bombarding energy, no resonance behaviour was observed. The angular distributions of the proton groups were analysed in terms of Legendre polynomials. The shape of them are asymmetrical about 90°, in general, slightly vary with the deuteron energy. The measured absolute total cross-section data of the proton groups are shown in Table 1. The estimated errors are less than 20 %.

Table 1

Energy /keV/	Cross-section of proton groups /μb/				
	p_o	p_1+p_2	p_3	p_4	p_5
626	1210	2000	860	3240	9050
576	780	1080	550	2100	6450
475	341	395	215	820	2800
374	76	86	37	142	580
324	25,1	26,6	12,2	46	201

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The DWBA analysis and the theoretical evaluation of the experimental data of proton groups are going on.

The groups α_2 and α_3 leading to the second and the third excited levels in the residual nucleus ^{12}C could not be measured using the same semiconductor detector technique because of the intense proton groups from other competing /d,p/ reactions on ^{14}N, ^{16}O and ^{12}C. Solid state track detectors [1] were used to measure the angular distributions of the groups α_o,α_1,α_2 and α_3 at incident deuteron energies E_d = = 350, 510 and 650 keV. The measured absolute total cross sections of the α groups are given in Table 2. The absolute errors are less than 20%.

Table 2

Energy /keV/	Cross-sections of alpha groups /μb/			
	α_o	α_1	α_2	α_3
650	1048	3283	181	3587
510	322	991	61.9	1103
350	19.0	74.3	5.63	66

The shape of the measured angular distributions does not change in the investigated energy region. The strong forward peak in the angular distirubtions of the group α_o and the relatively low cross section of the group α_2 demand detailed treatment which is now in progress.

[1] L. Meskó, B. Schlenk, G. Somogyi and A. Valek, Nucl. Phys., A130, 449 1969

CENTRAL RESEARCH INSTITUTE FOR PHYSICS

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BUDAPEST

THE MAGNETIC FIELD AT TUNGSTEN NUCLEI IN IRON

J.A. Cameron[*], *L. Keszthelyi, G. Mezei, Z. Szőkefalvi-Nagy and L. Varga*

Published in Canadian Journal of Physics

Larmor precession of the first 2^+ states of ^{182}W and ^{184}W has been observed in an iron alloy containing 5 atom percent W. The levels were Coulomb excited with 2.5 MeV protons. The hyperfine energy in ^{182}W is the same as that found by Mössbauer absorption. The variation of the field up to $300^{\circ}K$ is less than 6%. A comparison of g factors measured by hyperfine field and external field suggests the existence of a hyperfine anomaly.

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MAGNETIC MOMENTS OF THE 295 keV AND 357 keV STATES OF ^{103}Rh

L. Keszthelyi, I. Demeter, Z. Szőkefalvi-Nagy, L. Varga and G. Mezei

To be published in Nucl. Phys.

The g-factor of the 295 keV and 357 keV excited states of ^{103}Rh measured by Coulomb excitation in Fe-Rh alloy were found to be 0,28 ± 0,20 and 0,54 ± 0,05, respectively. The cascade decay of the 357 keV level was carefully taken into account in the evaluation of the 297 keV energy data.

g-FACTORS OF THE 211 AND 240 keV STATES OF ^{195}Pt

L. Varga, I. Demeter, L. Keszthelyi, G. Mezei, Z. Szőkefalvi-Nagy

Published in Phys. Rev.

The statistical accuracy of earlier results was improved by new measurements on $Fe_{72,5}Pt_{27,5}$ and $Fe_{50}Pt_{50}$ targets. In re-evaluating the data, corrections were made for beam bending and beam shift and new data regarding the decay scheme of ^{195}Pt were taken also into account. The g-factors of the 211 and 240 keV states of ^{195}Pt were found to be 0,104 $\pm$ 0,021 and 0,146 $\pm$ 0,019, respectively, in disagreement with current theoretical predictions. The value of the strength of the hyperfine magnetic field at Pt nuclei in the $Fe_{72,5}Pt_{27,5}$ alloy is in agreement with static measurements, it is -870 $\pm$ 60 kGauss for $Fe_{50}Pt_{50}$ alloy.

CORRELATION OF THE PARTIAL RADIATIVE AND NEUTRON WIDTHS IN THE $^{163}Dy/n,\gamma/^{164}Dy$ REACTION

L.S. Danelyan[x], A.M. Demidov[x], S.V. Krupin[x], S.K. Sotnikov[x], A. Zarándi, B. Kardon, L. Szabó, Z. Seres

ZhETF 62, /1972/ 425

The gamma-ray spectra in the $^{163}Dy/n,\gamma/^{164}Dy$ reaction are investigated with a Ge/Li/ spectrometer. A number of phenomena of non-statistical nature are observed: correlation between the reduced radiative and neutron widths and between various partial radiative widths. The absolute mean reduced partial width is greater than any of those predicted by various models or based on the experimental data for other nuclei. The degree of freedom of the partial width distribution to the ground rotational and γ-vibrational band is $\nu = 2 \pm 0.5$.

x Kurchatov Institute of Atomic Energy, Moscow

EFFECTS OF LEVEL STRUCTURE ON THE INTENSITY OF PARTIAL RADIATIVE TRANSITIONS IN THE $^{155}Gd/n,\gamma/^{156}Gd$ RESONANCES

L.S. Danelyan[x], *B. Kardon, S.K. Sotnikov*[x]

ZhETF, 62, /1972/ 1228

Intensity of the partial radiative transitions in resonances of the $^{155}Gd/n,\gamma/^{156}Gd$ reaction are studied by means of a Ge/Li/ -spectrometer. The correlation observed between the widths for transitions to levels of the ground state rotational band and the reduced neutron widths are discussed from the point of view of a semi-microscopic nuclear model.

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THE INFLUENCE OF QUANTUM NUMBER K ON THE INTENSITY OF PARTIAL GAMMA TRANSITIONS FROM THE $^{177}Hf/n,\gamma/^{178}Hf$ REACTION AT THE NEUTRON RESONANCES

L.S. Danelyan[x] *and B. Kardon*

To be published

The study of neutron capture gamma-ray spectra at the neutron resonances gives information on the highly excited nuclear levels. With the use of a lithium drifted germanium detector the partial radiations were measured at the neutron resonances with spin $J = 4^-$ up to a neutron energy of 100 eV, to the low-lying levels with different K quantum number.

[x] *Kurchatov Institute of Atomic Energy, Moscow*

THERMAL NEUTRON CAPTURE GAMMA-RAY STUDIES OF NATURAL Xe

B. Kardon, I.A.A. Manuaba, P. Gróz

Report KFKI-71-46

The gamma radiations following thermal neutron capture in natural xenon have been studied using a Ge/Li/ spectrometer at WWRS type research reactor. Solid XeF_2 was used as the target. The gamma-ray energies and intensities of 145 transitions in the energy range 0,2 - 9,3 MeV were determined. The energies have been obtained with an accuracy ranging between 0,1 keV for intense transitions and 5 keV for very weak transitions. The neutron separation energies of ^{130}Xe and ^{132}Xe have been deduced to be 9300,7 $\pm$ 1,8 keV and 8940,6 $\pm$ 1,1 keV, respectively.

MEASUREMENT OF GAMMA-RAY SPECTRA FROM THE SPONTANEOUSLY FISSIONING ISOMER OF ^{236}U

A. Lajtai, L. Jéki, Gy. Kluge and I. Vinnay

Measurements are in progress to detect gamma-ray transitions preceding spontaneous fission of the isomeric state of ^{236}U. The energy spectra between 200 keV and 1 MeV of gamma rays from $^{235}U/n_{th}$,gamma f/ reaction are studied to observe single lines corresponding to prefission gamma decays, using a fast-slow coincidence system. The gamma rays were detected with a 30 cm^3 Ge/Li/ detector, the fission fragments with a gas scintillation counter.

ENERGY SPECTRA OF NEUTRONS FROM /n,n'/ AND /n,2n/REACTIONS

Gy. Kluge and L. Jéki

Report KFKI-72-17

Energy spectra of neutrons from /n,n'/ and /n,2n/ reactions induced by 14 MeV neutrons have been calculated in terms of the original Weisskopf model for a number of target nuclei. The results of the calculations which avoid the usual approximations show very good agreement with the experimental data.

PROMPT FISSION NEUTRON SPECTRA

Gy. Kluge

Report KFKI-71-55

Some of the main features of the present theoretical understanding of the fission neutron spectra are discussed. The effect of a possible center-of-mass anisotropy and the validity of Terrell's T/ν/ relation are discussed. Results of some calculations on the prompt neutron spectra are given.

ON THE EMISSION OF PROMPT FISSION NEUTRONS

Gy. Kluge

Physics Letters 37B/1971/217

Different approaches, including a detailed cascade calculation of the centre of mass spectra of fission neutrons emitted from the individual fragments of spontaneous fission of ^{252}Cf, are compared in the determination of the total energy and angular distributions of fission neutrons. The existence of scission neutrons is questioned and the corrections arising from the form of the approach are discussed.

/n,2n/ CROSS SECTIONS ON Nb AND Mo NUCLEI

L. Jéki and Gy. Kluge

Submitted to the Journal of Nuclear Energy

Niobium and molybdenum are key structural materials in proposed designs for a D-T fusion reactor blanket, but implementation of such plans is hindered considerably by the lack of accurate cross-section values and energy distributions of neutrons in the /n,n'/ and /n,2n/ reactions of these elements. These data have been obtained by recently advanced calculation methods.

REMARKS ON THE EXISTENCE OF RETARDED NEUTRONS IN FISSION

L. Jéki, Gy. Kluge, A. Lajtai

Report KFKI-71-35

New measurements on the fine structure of the fission neutron spectrum are critically discussed.

UNFOLDING NEUTRON SPECTRA FROM ACTIVATION DATA

A. Fischer, L. Turi

The neutron spectra are unfolded from activation data by the code RFSP [1]. The main problems which are now investigated are connected with the compilation of reliable activation cross section data for the detector foil materials. The new cross section data are continuously incorporated in the cross section library of the code. Preliminary results show, that some discrepancies discovered in connection with the use of this method are probably due to incorrect detector cross section data.

[1] A.Fischer, L.Turi: Report KFKI-71-22

COMPILATION OF MUFT-TYPE MULTIGROUP CONSTANT LIBRARY

P. Vértes

Since the last Progress Report /1971/ little has been done as the compilation of new multigroup constant library concerned. What is going on now is a thorough check of the new compilation /on which it was reported in the Progress Report of last year/ by using it for the calculation of multigroup neutron spectra and by comparison of the calculated spectrum indices and other important parameters with experimental results. It is found that this new compilation represents an important improvement with respect to our old group constant library.

Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Erő János, a KFKI Magfizikai
Tudományos Tanácsának elnöke
Példányszám: 75 Törzsszám: 6791
Készült a KFKI házi sokszorosító üzemében,
Budapest, 1972. május hó