458

NOT FOR PUBLICATION

INDC(JAP) 10E
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PROGRESS REPORT

(July 1970 to June 1971 inclusive)

August 1971

edited by

T. Momota

aided by

T. Fuketa and S. Tanaka

Japanese Nuclear Data Committee

Japan Atomic Energy Research Institute

Tokai Research Establishment

Tokai-mura, Ibaraki-ken, Japan

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Editor's Note

This is a collection of reports which have been submitted to the Japanese Nuclear Data Committee at the Committee's request. The request was addressed to the following individuals who might represent or be in touch with groups doing researches related to the nuclear data of interest to the development of the nuclear energy program.

Although the editor tried not to miss any appropriate addressees, there might have been some oversight. Meanwhile, contribution of a report rested with discretion of its author. The coverage of this document, therefore, might not be uniform over the related field of research.

This edition covers a period of July 1, 1970 to June 30, 1971. The informations herein contained are of a nature of "Private Communication." They should not be quoted without author's permission.

Addressees of the request (in Alphabetical order):

1) Electrotechnical Laboratory
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   (E. Teranishi)

2) Hiroshima University
   Faculty of Science / 1-1.89 Higashisenda, Hiroshima
   (N. Ryu)

3) Hitachi Ltd.
   Central Laboratory / Oozenji, Kawasaki-shi, Kanagawa
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   Tokai Research Establishment / Tokai-mura, Naka-gun, Ibaraki
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   c) Research Reactor Institute / Kumatori, Sennan-gun, Osaka
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   a) Faculty of Science / Hakozaki-cho, Fukuoka
      (A. Isoya)

b) Faculty of Engineering / Hakozaki-cho, Fukuoka

(M. Sonada)

8) Mitsubishi Atomic Power Industries Inc.

Engineering and Development Division / Kitafukuro, Omiya-shi, Saitama

(T. Iwaki)

9) Nagoya University

Faculty of Engineering / Furo-cho Chigusa-ku, Nagoya

(T. Katoh)

10) Niigata University

Faculty of Science / 8050 Nino-cho, Igarashi, Niigata

(N. Mutsuro)

11) Nippon Atomic Industry Group Co., Ltd.

Nuclear Research Laboratory / 250 Sueriro-cho, Kawasaki-shi, Kanagawa

(S. Iijima, N. Kawai)

12) Osaka University

a) Faculty of Engineering / Yamadaue, Suita-shi, Osaka

(T. Sekiya)

b) Faculty of Science / 1-1, Machikaneyama, Toyonaka-shi, Osaka

(T. Wakatsuki, M. Muraoka)

13) Radiation Center of Osaka Prefecture

Shinya-cho, Sakai-shi, Osaka

(T. Azuma)

14) Rikkyo (St. Paul's) University

a) Department of Physics / 3, Ikebukuro, Toshima-ku, Tokyo

(I. Ogawa)

b) Institute for Atomic Energy / Sajima, Yokosuka-shi, Kanagawa

(M. Hattori)

15) The Institute of Physical and Chemical Research

2-1, Hirosawa, Wako-shi, Saitama

(M. Kodera)

16) Tohoku University

a) Faculty of Science / 75 Katahira-cho, Sendai-shi, Miyagi
(S. Morita)

b) Laboratory of Nuclear Science / 1 Tomisawa, Kanayama, Sendai-shi, Miyagi
(M. Kimura)

17) Tokai University

Faculty of Engineering / 2-28-4 Tomigaya, Shibuya-ku, Tokyo
(Y. Kuroda)

18) Tokyo Institute of Technology

a) Faculty of Science / 2-12-1 Ohokayama, Meguro-ku, Tokyo
(Y. Oda)

b) Research Laboratory of Nuclear Reactor / 2-12-1 Ohokayama
(N. Yamamuro)

19) Tokyo University of Education

Faculty of Science / 3-29-1 Ohtsuka, Bunkyo-ku, Tokyo
(J. Sanada, K. Katori)

20) University of Tokyo

a) Faculty of Science / 7-3-1 Hongo, Bunkyo-ku, Tokyo
(Y. Nogami)

b) Institute for Nuclear Study / 3-2-1 Midori-cho, Tanashi, Tokyo
(Y. Saji, Y. Ishizaki)

c) College of General Education / 865 Komaba, Meguro-ku, Tokyo
(T. Terasawa)

21) Waseda University

Department of Applied Physics / 17 Kikui-cho, Shinjuku-ku, Tokyo
(M. Yamada)

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ELEMENT S A	QUANTITY	TYPE	ENERGY(eV) MIN	MAX	DOCUMENTATION REF VOL PAGE DATE	LAB	COMMENTS
C	DIFF ELASTIC	EXPT-PROG	2.0 7		EANDC(J)22L,10 8/71	JAE	YAMANOUTI+.4-DETECTOR TOF.NDG
C	TOTAL XSECT	REVW-PROG	1.0 0	2.0 6	EANDC(J)22L,22 8/71	JAE	NISHIMURA+.LST-SQ FIT BY 4TH POLYNOM
C 012	DIFF ELASTIC	THEO-PROG	0	4.5 6	EANDC(J)22L,43 8/71	TKO	MIKOSHIBA+.COUPLED-CHAN CAL FOR RES
C 012	DIFF INELAST	EXPT-PROG	2.0 7		EANDC(J)22L,10 8/71	JAE	YAMANOUTI+.4-DETECTOR TOF.NDG
N	DIFF ELASTIC	EXPT-PROG	1.4 7		EANDC(J)22L,30 8/71	KYU	HYAKUTAKE+.SIG CFD C OPT-MDL
N 014	DIFF INELAST	EXPT-PROG	1.4 7		EANDC(J)22L,30 8/71	KYU	HYAKUTAKE+.FOR 4-STATES+3-GROUPS.NDG
O	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
O	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
NA	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
NA	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
CR	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
CR	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
FE	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
FE	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
NI	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
NI	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
CU	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.NDG
GE	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.NDG
ZR 090	N2N XSECTION	EXPT-PROG	1.3 7	1.5 7	EANDC(J)22L,32 8/71	KYU	KANDA.SIG FOR ISOM + ISOM-RATIOS.NDG
MO 092	N,ALPHA	EXPT-PROG	1.3 7	1.5 7	EANDC(J)22L,32 8/71	KYU	KANDA.SIG FOR GR+ISOM.NDG
MO 092	N,PROTON	EXPT-PROG	1.3 7	1.5 7	EANDC(J)22L,32 8/71	KYU	KANDA.ANALD C STATIST MDL.NDG
MO 092	N2N XSECTION	EXPT-PROG	1.3 7	1.5 7	EANDC(J)22L,32 8/71	KYU	KANDA.SIG FOR GR+ISOM.NDG
RH 103	TOT INELASTC	EXPT-PROG	PILE		EANDC(J)22L,26 8/71	KTO	KIMURA+.AVG SIGMA=560+-7 BARN
AG	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
IN	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
IN 115	TOT INELASTC	EXPT-PROG	PILE		EANDC(J)22L,26 8/71	KTO	KIMURA+.AVG SIGMA=175+-2 BARN
SN	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
SN 120	DIFF ELASTIC	EXPT-PROG	1.5 6	3.5 6	EANDC(J)22L,10 8/71	JAE	TANAKA+.TOF IN 500-KEV STEP.NDG
SN 120	DIFF INELAST	EXPT-PROG	1.5 6	3.5 6	EANDC(J)22L,10 8/71	JAE	TANAKA+.TOF IN 500-KEV STEP.NDG
SB	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
TE	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
CS 133	INELAST GAMMA	EXPT-PROG	6		EANDC(J)22L,11 8/71	JAE	KIKUCHI.ANG-DISTR+EXC-F CFD C TH.NDG
LA 139	DIFF ELASTIC	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.OKS COUPLED-CHAN CAL
LA 139	DIFF INELAST	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.MEASURED IN 500-KEV STEP.NDG
PR 141	DIFF ELASTIC	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.OKS COUPLED-CHAN CAL
PR 141	DIFF INELAST	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.MEASURED IN 500-KEV STEP.NDG

ELEMENT S A	QUANTITY	TYPE	ENERGY (eV) MIN	MAX	DOCUMENTATION REF VOL PAGE DATE	LAB	COMMENTS
SM	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
EU 151	ACTIVATION	EXPT-PROG	PILE		EANDC(J)22L,15 8/71	JAE	SUZUKI+.G-ENERG+INTENS FROM EU-152G
GD	DIFF ELASTIC	EXPT-PROG	1.5 6	3.5 6	EANDC(J)22L,10 8/71	JAE	TANAKA+.TOF IN 500-KEV STEP.NDG
GD	DIFF INELAST	EXPT-PROG	1.5 6	3.5 6	EANDC(J)22L,10 8/71	JAE	TANAKA+.TOF IN 500-KEV STEP,NDG
HO	PHOTO-FISS	EXPT-PROG	2.5 8	1.0 9	EANDC(J)22L,33 8/71	KYU	KATASE.SIG IN FIG
ER	DIFF ELASTIC	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.OKS NON-SPHERICAL OPTMDL CAL
PB 208	GAMMA,N	EXPT-PROG	5		EANDC(J)22L, 2 8/71	JAE	MIZUMOTO+.TOF,SPIN-PARITY ASSIGNED
BI 209	DIFF ELASTIC	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.OPT-POT PARAMETERS SEARCHED
BI 209	DIFF INELAST	EXPT-PROG	1.5 6	3.6 6	EANDC(J)22L, 3 8/71	JAE	TANAKA+.MEASURED IN 500-KEV STEP.NDG
U	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
U	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
U 235	ALPHA	EXPT-PROG	PILE		EANDC(J)22L,12 8/71	JAE	NATSUME+.RAD-CHEM ANAL.MEAN-VAL GIVN
U 238	FRAG CHARGE	EXPT-PROG	1.3 7	5.5 7	EANDC(J)22L,14 8/71	JAE	UMEZAWA.CHARGE DISPERSION CURVE GIVN
U 238	FISS YIELD	EXPT-PROG	1.3 7	5.5 7	EANDC(J)22L,13 8/71	JAE	BABA+.MASS-DISTR+SIG BY (P,F).NDG
NP 237	FISSION	EXPT-PROG	PILE		EANDC(J)22L,26 8/71	KTO	KIMURA+.AVG SIGMA=1.33+-0.11 BARN
NP 237	FISSION	EXPT-PROG	1.5 7		EANDC(J)22L,14 8/71	JAE	TAKEKOSHI.NO FISS ISOM BY (N,2N).NDG
PU	DIFF ELASTIC	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
PU	DIFF INELAST	COMP-PROG			EANDC(J)22L,23 8/71	JAE	IGARASI+.DATA COMPILATION.NDG
CF 252	FISS YIELD	EXPT-PROG			EANDC(J)22L,34 8/71	KYU	KATASE+.ALPHA SPECT AT 90-DEG IN FIG
MANY	N,GAMMA	REVW-PROG	3	5	EANDC(J)22L,36 8/71	JAP	IIJIMA+.LUMPED SIG OF FAST-FISS-PROD
MANY	N,GAMMA	THEO-PROG			EANDC(J)22L,39 8/71	OSA	MATSUOKA+.(N-Z)DEPENDENCE.NO RESULT
MANY	F NEUT DELAY	THEO-PROG			EANDC(J)22L,45 8/71	JAP	TAKAHASHI.DELAYED-N EMISS RATE
MANY	F NEUT DELAY	THEO-PROG			EANDC(J)22L,40 8/71	TOH	NAKAYA+.SEMI-EMPIRICAL EQ OF N-EMIT
MANY	RESON PARAMS	THEO-PROG			EANDC(J)22L,14 8/71	JAE	IDENO+.CORRELATION OF RES SPACE.NDG
MANY	TOTAL XSECT	REVW-PROG	1.0 5	1.5 7	EANDC(J)22L,23 8/71	JAE	IGARASI+.Z=33-73,OPT-MDL ANAL.NDG
MANY	THRMSCATLAW	REVW-PROG			EANDC(J)22L,25 8/71	JAE	/JNDC 3RD ED BIBLIOGRAPHY THR N SCAT
MANY	THRMSCATLAW	THEO-PROG	THR		EANDC(J)22L,20 8/71	JAE	/NAKAHARA+.SCATT KERNEL AT HIGH TEMP
H2O	THRMSCATLAW	THEO-PROG	THR		EANDC(J)22L,19 8/71	JAE	/GOTOH+.ITINERANT OSCILLAT MODEL NDG

I. Japan Atomic Energy Research Institute

A. Neutron Experiments-Linac

I-A-1. Electron Linear Accelerator

JAERI Linac Laboratory

The JAERI 20-MeV Electron Linac, which had been operated since the end of 1960, was shut down in March 1970 and was dismembered. A 120-MeV s-band electron linear accelerator is now under construction at the same laboratory of JAERI, and the linac is scheduled to start the test operation early in 1972. The linac consists of two 2-m and three 3-m waveguide sections and is powered by five 20-MW klystrons. Although the accelerator waveguide tubes, the klystrons, the pulse transformers, and so forth are purchased, the new linac is being assembled by the staffs of the JAERI Linac Laboratory.

The main purpose of this linac is the neutron cross-section measurements, however, other experiments on nuclear physics, solid state physics, reactor physics, radiation chemistry and so on will also be made. The linac electron beam will be branched off into three target sections, one for a neutron generating target, for electron beam and slow neutron experiments, and for production of radioisotopes, reactor physics, and photonuclear experiments. Eight neutron beam holes for the time-of-flight paths are installed at the neutron generating target section. The time-of-flight detector sheds are newly built at 47, 55, 100, and 190 meters from the target. The partial reconstruction of the old linac building and the construction of the detector sheds were finished in June 1971, and the accelerator waveguide tubes were delivered to the laboratory in the same month. A computer system with 16K 22-bit words core memory, a 64K-word magnetic drum, and two 9-track 800 BPI tape drives will also be operational for on-line data acquisition of the linac experiments early in 1972.

I-A-2. $^{208}Pb(\gamma,n)$ ^{207}Pb Reaction near Threshold

M. Mizumoto, Y. Nakajima, R. Bergère*, and T. Fuketa

A paper on this subject is to be published in JAERI-memo 4520 with an abstract as follows:

The photoneutron cross section for ^{208}Pb has been studied in several hundred keV region of neutron energy by means of the neutron time-of-flight technique. Spins and parities of the compound levels were determined by measuring the angular distribution of emitted neutrons, and the ratios of reaction matrix elements for channel spin 1 and 0 were calculated for the excited states of 1^+ of ^{208}Pb.

* Visiting scientist from C.E.N. de Saclay. Now at Département de Physique Nucléaire / MF, C.E.N. de Saclay, France.

B. Neutron Experiments-Van de Graaff Accelerator

I-B-1. Fast Neutron Scattering from ^{139}La, ^{141}Pr, Er and ^{209}Bi

S. Tanaka, Y. Tomita, K. Ideno and S. Kikuchi

Differential cross sections for elastic and inelastic neutron scattering have been measured for natural samples of La, Pr, Er and Bi at incident energies from 1.5 to 3.5 MeV in about 500-keV steps. Scattered neutrons were observed at angles from 30^{o} to 150^{o} (or 147^{o}) in 10^{o} steps with a time-of-flight spectrometer. Neutrons were generated by the $^{3}H(p,n)^{3}He$ reaction. The target was a 3-cm long gas cell filled with tritium gas at 53 cmHg. The energy spreads of the neutrons incident on the samples were 35 to 60 keV.

The absolute differential cross-section scale was fixed with reference to the n-p scattering cross section[1)]. Peaks unresolved in the time spectra were separated using a peeling-off method. The data were corrected for flux attenuation, multiple scattering in the samples and source-to-sample angular spread using the Monte Carlo method. The differential elastic cross sections thus obtained are shown by closed circles in Fig. 1-4. In Fig. 4 open circles indicate the elastic plus the inelastic cross sections for the first levels in Er isotopes, because the first levels are too close-lying to the ground level to be resolved.

The differential elastic-scattering cross sections were analysed using both the spherical optical model and the coupled-channels theory.[2)] The optical-potential form used was of standard type with a Saxon-derivative imaginary part and with a spin-orbit coupling term. The compound-elastic cross sections were estimated by the Hauser-Feshbach[3)] or corrected Hauser-Feshbach (Moldauer)[4)] calculations. The analysis was made in the following steps:

(1) For ^{209}Bi the potential depths of the real part V and the imaginary part W were searched by means of an automatic searching routine at each incident energy so that the results of the optical-model calculations were fitted to the total cross section and the elastic data; the other parameters being fixed.

(2) An overall-fit parameter set was obtained by taking respective average values of V and W.

(3) It was ascertained that there was no large difference between the result of the spherical-potential calculation and the result of the coupled-channels calculation for the elastic scattering of ^{209}Bi, and that the Hauser-Feshbach or the Moldauer calculations well reproduced the observed inelastic data for the first and second excited levels (the inelastic cross sections are not shown in this report).

(4) Using the overall-fit set, both the spherical-potential and coupled-channels calculations were performed and the results were compared with the observed elastic data for ^{139}La, ^{141}Pr and Er.

The calculations with the spherical optical-model potential and the Hauser-Feshbach theory were made by using the computer code STAX2[5]. The coupled-channels calculations were performed with the computer code JUPITOR-1[6]. The overall-fit parameter set was obtained as follows: $V = 46.0$ MeV, $a = 0.65$ fm, $W = 4.3$ MeV, $b = 0.48$ fm, $V_{so} = 7.0$ MeV and $r_o = 1.25$ fm.

In Figs. 1-4, the spherical-potential calculations are shown by dashed curves, and the coupled-channels calculations by solid curves. In the latter calculations for ^{209}Bi, the coupling between the ground level and the seven close-lying levels near excitation energy 2.58 MeV relevant to octupole vibration were considered, and the value of β_3 was taken as 0.10[7].

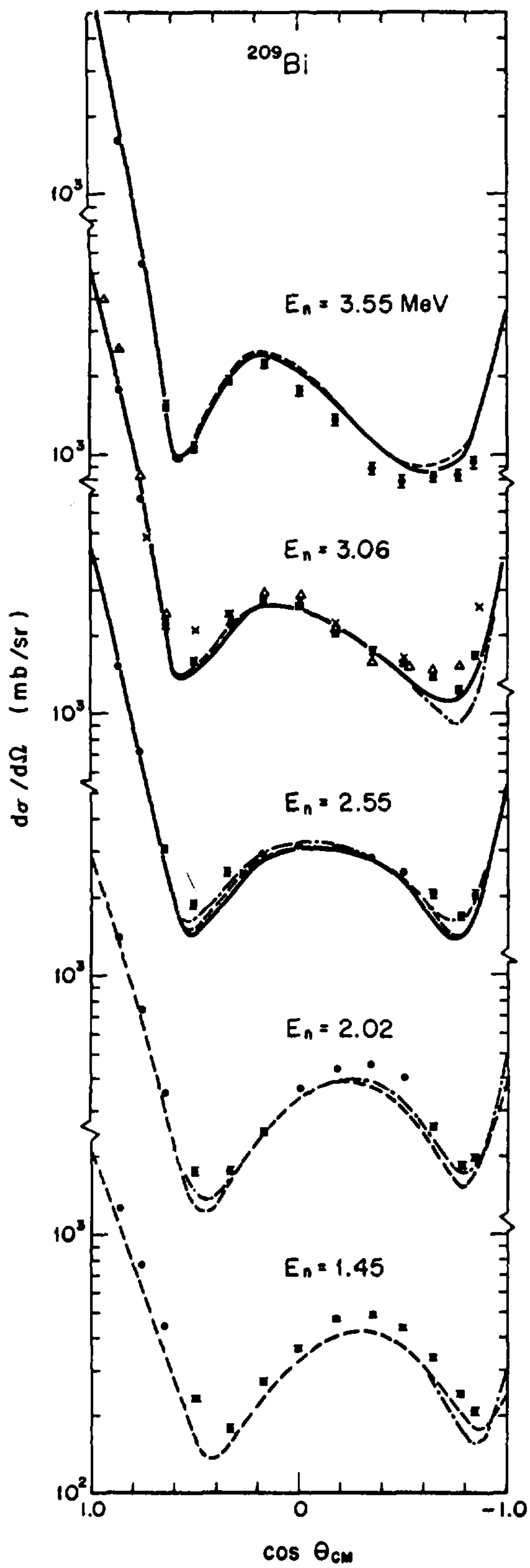

Fig. 1

Differential cross sections for elastic scattering by ^{209}Bi. The closed circles represent the experimental data. The crosses and triangles are data of Popov[9] and Becker et al.[10], respectively. The dashed curves are cross sections calculated with the spherical optical-model potential and the solid curves with the coupled-channels theory. The compound-elastic cross sections calculated with the Hauser-Feshbach formula were added to both calculated results. The dash-dot curve indicates that the compound-elastic part was calculated with the modified Hauser-Feshbach formula.

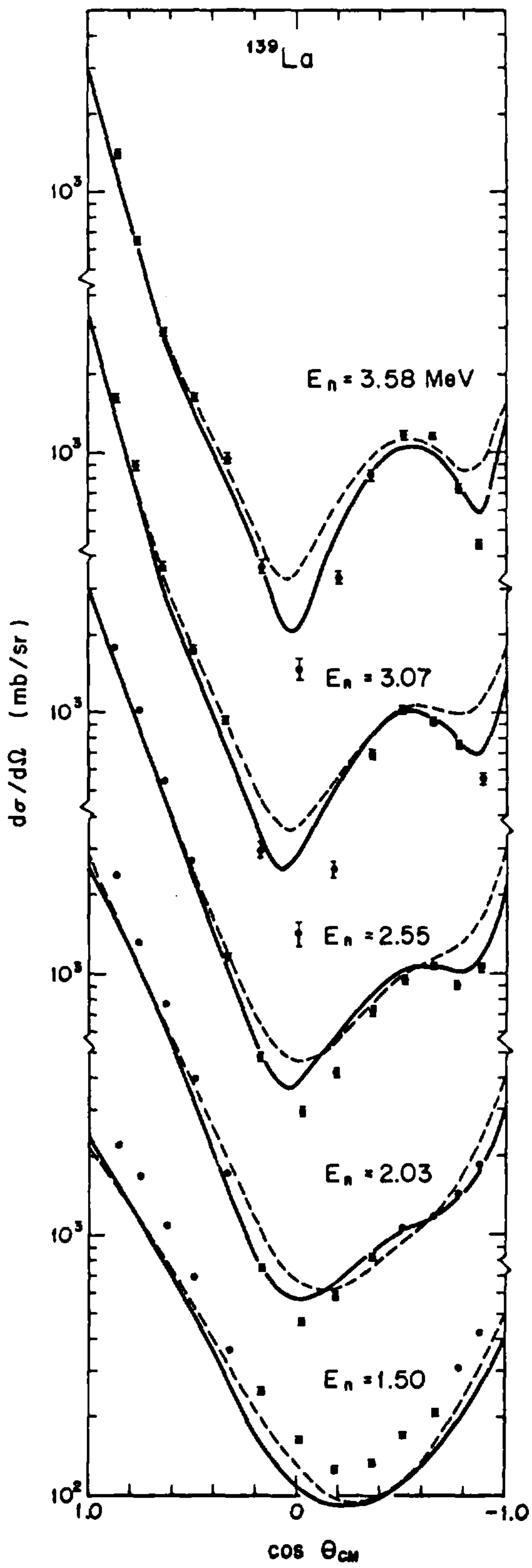

Fig. 2
Differential cross sections for elastic scattering by ^{139}La. The closed circles represent the experimental data. The solid and dashed curves have the same meaning as in Fig. 1.

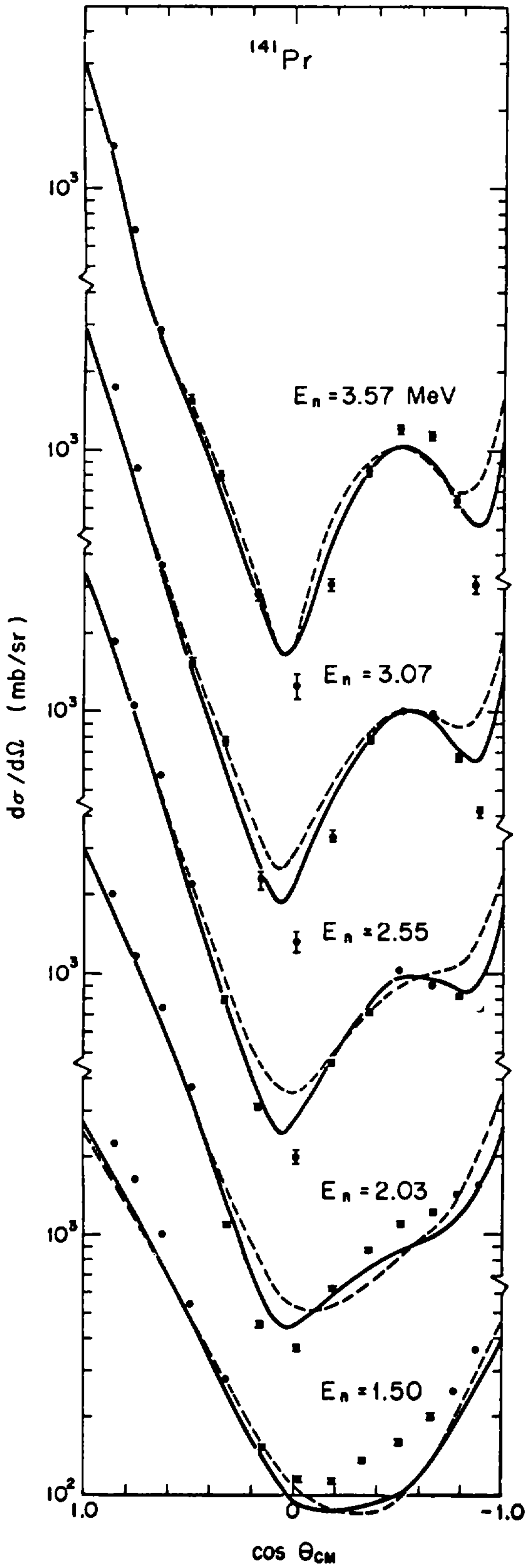

Fig. 3

Differential cross sections for elastic scattering by ^{141}Pr. The closed circles represent the experimental data. The solid and dashed curves have the same meaning as in Fig. 1.

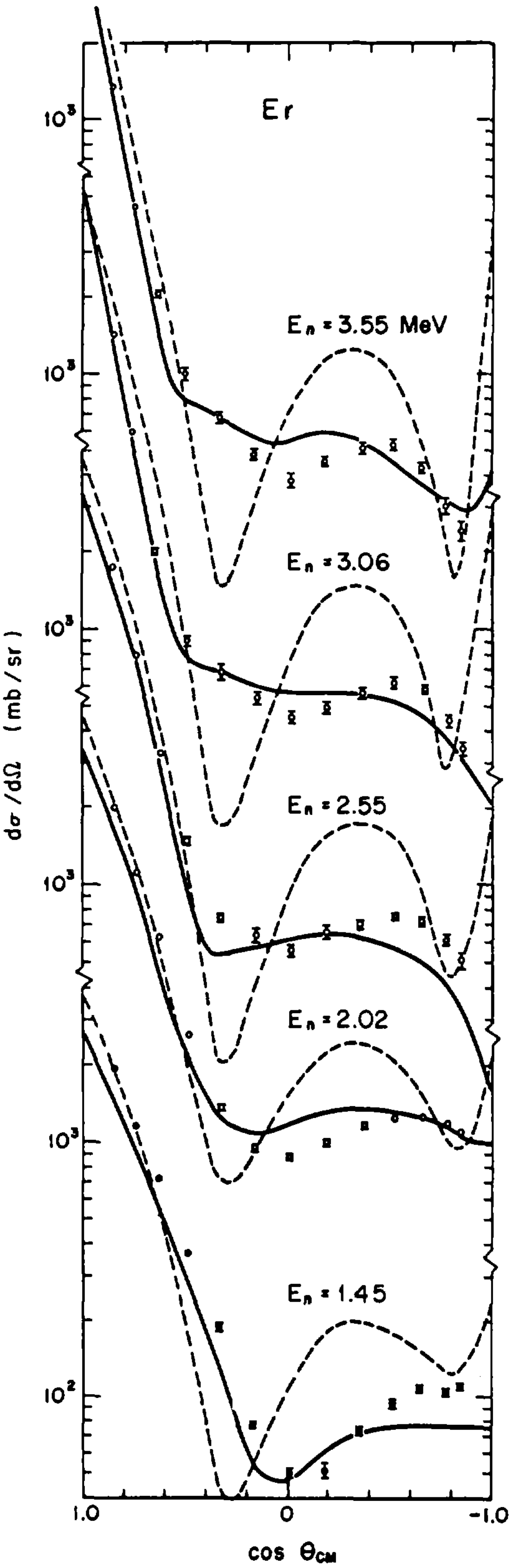

Fig. 4

Differential cross sections for elastic scattering by Er. The closed circles represent the experimental elastic data. The open circles indicate the elastic plus the inelastic cross sections for the first levels in erbium isotopes. Accordingly, the direct inelastic cross sections for the first 2^+ levels calculated with the coupled-channels theory were added to the elastic cross sections calculated with the coupled-channels theory. The solid curves, except for the case of En = 1.45 MeV, represent such combined cross sections. The dashed curves are cross sections calculated with the spherical optical potential. The compound-elastic contributions were neglected in the case of En = 3.55, 3.06 and 2.55 MeV.

For ^{139}La, we took the core-excitation model assuming that a spin-7/2 proton weakly coupled to a vibrational ^{138}Ba core, and the coupling between the ground level and the first 2^+ level of ^{138}Ba was considered. The value of β_2 was taken as 0.12[8]. For ^{141}Pr, a similar assumption was made, and the value of β_2 was taken as 0.104[8]. Figs. 2 and 3 show that the coupled-channels calculations are more favourable than the spherical optical-model calculations, in the energy region above 2.0 MeV.

In the coupled-channels calculation for Er, even isotopes of Er were assumed to be deformed and the ground rotational band up to 6^+ level was considered with adiabatic approximation. The value of β_2 was taken as 0.34[8]. Fig. 4 shows that the results of the coupled-channels calculations give rather better agreement with the experiment than the spherical optical-model calculations. In all the coupled-channels calculations mentioned above, the coupling terms were taken to be complex.

A full paper of this work is now under preparation and will be submitted to "Nuclear Physics".

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I-B-2. Fast Neutron Scattering from ^{120}Sn and Gd

S. Tanaka, Y. Tomita, Y. Yamanouti and K. Ideno

Measurement of the differential cross sections for elastic and inelastic scattering of neutrons from a sample of separated isotope ^{120}Sn and a natural sample Gd has been completed at neutron energies of 1.5 to 3.5 MeV in 500 keV steps. Scattered neutrons were observed at angles from 25° to 145° in 10° steps using a three-detector time-of-flight spectrometer with 8-m flight paths. Data analysis is now progressing.

I-B-3. Elastic and Inelastic Scattering of Neutrons in 20 MeV Region

Y. Yamanouti, S. Tanaka, Y. Tomita, S. Kikuchi and K. Tsukada

A multi-angle time-of-flight spectrometer for the detection of fast neutrons has been constructed. The spectrometer has four detectors which are placed in 10° steps and mounted upon a large turn table with maximum flight paths of 8 m.

Electronic circuits are those of conventional time-of-flight techniques with neutron gamma-ray pulse shape discrimination. Output signals from four detectors are identified by Packard 32 Input Selective Storage Unit and fed into 4096 ch pulse height analyzer.

Results of test experiments for carbon have shown this spectrometer capable of obtaining differential elastic and inelastic neutron scattering information in 20 MeV region.

I-B-4. Energy Levels of ^{133}Cs Excited by Means of the (n,n'γ) Reaction

Shiroh Kikuchi

The energy levels of ^{133}Cs were studied by means of the (n,n'γ) reaction in the energy range 0.5 - 1.2 MeV. Nine levels of 605 ($11/2^-$), 633 ($11/2^+$), 641($3/2^+$), 706($7/2^+$ or $9/2^+$), 768($7/2^+$ or $9/2^+$), 787($7/2^+$ or $9/2^+$), 819($5/2^+$, $7/2^+$ or $9/2^+$), 873($7/2^+$ or $9/2^+$) and 941($3/2^+$ or $5/2^+$) keV were found. The spin and parity assignments were made by comparing the observed angular distributions of γ-rays and level excitation functions with those calculated on the basis of the statistical theory.

A full paper on the subject is to be published in Nuclear Physics.

C. Others

I-C-1. A Determination of Fission to Capture Ratio of ^{235}U for Pile Neutrons

H. Natsume, H. Okashita, H. Umezawa, and T. Komori

A fission to capture ratio of ^{235}U averaged for a long time irradiation with pile neutrons was measured. Five specimens were sampled from a fuel plate, which has been loaded for four years in the JRR-4, and analyzed for uranium and neodymium by an isotope dilution method and for plutonium by radiochemical means. The fuel uranium was of 89.92% enriched in ^{235}U and was alloyed and covered with aluminum. Information on the neutron field in this reactor core is given elsewhere.[1,2]

According to the definition of the initial atomic fraction of ^{236}U, R_6^o, the following relation is derived.

$$\frac{N_6 + N_n}{N_f} = R_6^o \left(1 + \frac{N_u + N_p + N_n + N_a}{N_f}\right) + \alpha_5$$

where N_f is the number of fissions and was determined from the accumulation of neodymium isotopes. N_6, N_u, and N_p are the number of atoms of ^{236}U, of total uranium, and of total plutonium, respectively, and were obtained from the analytical data. N_n and N_a are the number of atoms of ^{237}Np and of total amerisium which were negligible in this case.

Of this reactor fuel, the value of R_6^o was not recorded incidentally. However, assuming that the value of the fission to capture ratio of ^{235}U, α_5, is identical for these five specimens, a mean value of α_5 was found to be 0.195 ± 0.001 from the intercept in plotting the N_6/N_f ratio against the reciprocal of the burnup values which were ranging from 1.89 to 6.05%.

References:

1) K. Tomabechi, M. Morozumi, N. Onishi, H. Usuba, Y. Kosuge, S. Watanabe, JAERI-memo 2834 (1967).

2) M. Morozumi, H. Natsume, T. Sato, T. Suzuki, K. Tomabechi, and H. Umezawa, J. Nucl. Sci. Tech., 6(1969)551.

I-C-2. Mass Distribution and the Total Fission Cross Section in the Fission of ^{238}U with Protons of Energies Ranging between 13 and 55 MeV

S. Baba, H. Umezawa, and H. Baba

The paper on this subject is submitted for publication to Nucl. Phys. with an abstract as follows:

The fission of ^{238}U with protons of the energy ranging from 13 to 55 MeV was studied radiochemically. The mass-yield curve was obtained for each of the eleven incident energies, and was analyzed based on the two-mode-fission mechanism. The observed total chain yields were reasonably reproduced by the combination of the three Gaussian curves with partial distortions. The deduced number of neutrons emitted in fission was found to agree well with the postulated value in the study of the charge distribution systematics.[1)] For the three highest incident energies, the formation of the fissile nuclei through direct process was shown to occur and the analyzing method was discussed.

The peak-to-trough ratio and the total fission cross section were obtained from thus established mass distribution curves.

References:

1) H. Umezawa, S. Baba, and H. Baba, Nucl. Phys., A160 (1971)65.

I-C-3. Nuclear Charge Distribution in Proton-Induced Fission of ^{238}U

H. Umezawa

The paper on this subject is in press in the J. Inorg. Nucl. Chem. with an abstract as follows:

Fractional chain yields of ^{86}Rb, ^{132}Te, ^{134}Cs, ^{136}Cs, ^{140}Ba, ^{148}Pm, and ^{160}Tb were determined radiochemically in the fission of ^{238}U induced with 13- to 55-MeV protons. From investigation of the excitation energy dependence of these yield data, a common charge dispersion curve, $y = (2\pi\sigma^2)^{-1/2}\exp[-(Z-Zp)^2/2\sigma^2]$, was found valid for all mass chains throughout this energy range. The resulting values of $2\sigma^2$ were found to be 0.97 ± 0.06. The pre-fission neutron emission is also discussed in connection with the fragment mass ratio.

I-C-4. Search for Spontaneous Fissioning Isomer of ^{236}Np

Eiko Takekoshi

A paper on this subject was published in J. Phys. Soc. Japan 30 (1971) 284.

I-C-5. Nonrandom Distributions of Neutron Resonance Levels

K. Ideno and M. Ohkubo

A full paper on this work, which was outlined in the previous report titled as "Deviations from the Statistical Distributions of Neutron Resonance Levels of Intermediate and Heavy Nuclei" (EANDC(J) 19L, P. 15), was published in J. Phys. Soc. Japan 30 (1971) 620.

I-C-6. A Facility for Resonance-Fluorescence Experiments Using an Electron Linac

N. Shikazono and Y. Kawarasaki

A full paper on this subject was published in the Nuclear Instruments and Methods 92 (1971) 349-357 with an abstract as follows:

A facility for the study of resonant scattering of gamma rays is described. Bremsstrahlung gamma rays from an electron linac are used as the gamma-ray source and resonantly scattered gamma rays are detected by a Ge(Li) detector. Gamma rays scattered from ^{11}B are used for the energy calibration. The principal features and characteristics of the facility are discussed. Gamma-ray spectra resulting from the photon bombardment of boron and fluorine are shown. A method of determining radiative width is described.

I-C-7. Gamma-ray Energies and Relative Intensities from ^{152g}Eu for Ge(Li) Calibration

T. Suzuki, H. Baba, S. Baba and H. Okashita

Energies and relative intensities of the γ rays from ^{152g}Eu were determined. The 92% enriched ^{151}Eu was irradiated for two weeks with the neutron flux of $\sim 2 \times 10^{13}$ n/cm^2/sec and chemically purified by an ion exchange chromatography. Considering the neutron absorption cross sections of ^{151}Eu and ^{153}Eu and the enrichment factor of the target, it is clear that the interference due to photons from ^{154}Eu is practically negligible except for the 1.278 MeV photopeak. The ^{152g}Eu obtained was mounted on a thin Mylar film and sandwiched with Scotch tape.

The used γ ray spectrometer was a 50 cm^3 coaxial type Ge(Li) detector. The energy resolution of the detector was 2.8 keV at 1.332 MeV for ^{60}Co. Energy and efficiency calibration curves were constructed by measuring a set of the IAEA standard sources in the same geometry as ^{152}Eu. The low energy γ rays from ^{182}Ta were also used for the energy calibration. The peak positions were determined by the least squares fitting of the peak shape to the parabola[1)]. Peak areas were calculated by summation of the surplus peak-area above the compton continuum[2)]. The doublet of the 1086 and 1090 keV γ rays was, however, decomposed into each component by the least squares fit to the Gaussian function with overall fit of $\pm$ 0.01%.

The resulting relative intensities of the γ rays with relatively high yields are listed in Table 1 in comparison with the reported values. The quoted errors in the present work indicate merely the statistical errors. Table 2 shows the determined photon energies in the low energy region. The energy calibration curve was taken as the second order polynomial built up with ^{182}Ta, ^{113}Sn and ^{22}Na in the energy range between 0 to 510 keV. The internal error for the standard energies was found to be less than 1 eV. Errors in the ^{152}Eu photon energies therefore come mainly from the channel shift during the measurements. The channel shift was estimated not to exceed 0.2 channel; 100 eV equivalent in this case.

References:

1) A. Savitzky and M. J. E. Golay: Anal. Chem. 36 (1964) 1627.

2) H. Baba, H. Okashita, S. Baba, T. Suzuki, H. Umezawa and H. Natsume; J. Nucl. Sci. and Tech., to be published.

3) C. M. Lederer, J. M. Hollander and I. Perlman, eds: Table of Isotopes, 6-th ed. (1967) J. Wiley & Sons Inc., New York.

4) D. S. Dzhelepov, N. N. Zukovskii and A. G. Maloyan: Soviet J. Nucl. Phys. 3 (1966) 577.

5) L. Varnell, J. D. Bowman and J. Trischuk: Nucl. Phys. A127 (1969) 270.

6) G. Aubin, J. Barrette, M. Barrette and S. Monaro: Nucl. Instr. and Meth. 76 (1969) 93.

7) A. Notea and E. Elias: Nucl. Instr. and Meth. 86 (1970) 269.

8) R. S. Mowatt: Can. J. Phys. 48 (1970) 2606.

Table 1. Relative intensities of the photons in the decay of 12.4y ^{152g}Eu.

Energy (keV)	Relative intensity						
Lederer 3) et al.	Dzhelepov 4) et al.	Lederer 3) et al.	Varnell 5) et al.	Aubin 6) et al.	Notea 7) et al.	Mowatt 8)	Present Work
121.79	110±9	91	117±4	103.7±3.1	113.1±3.2	105.0±2.1	98.3±0.2
244.7	28±4	30	28.9±0.9	27.94±0.80	30.7±1.0	27.8±0.6	30.7±0.2
296	12±4	1.5	1.60±0.04	1.63±0.11	1.85±0.15		1.90±0.16
344.4	100	100	100	100	100	100	100
367	3.6±2.1	2.2	3.16±0.09	3.23±0.12	2.95±0.25		2.93±0.18
411.2	8±1	8.1	8.27±0.16	7.92±0.27	7.91±0.42	7.96±0.16	8.2±0.2
444.2	14±2	15	11.5±0.6	11.75±0.32	12.07±0.26	10.9±0.2	11.0±0.2
560			1.79±0.05				2.22±0.11
583			1.72±0.05				2.02±0.12
612							0.52±0.10
658			0.55±0.03				0.42±0.09
676			1.71±0.11				1.80±0.13
689		2.6	3.04±0.06				2.70±0.12
720			1.19±0.04				1.41±0.13
779	42±3	52	46.7±0.4	48.80±1.10		47.4±0.9	45.4±0.2
811			1.17±0.04				1.00±0.13
869		15	14.97±0.18				15.2±0.2
965	48±3	56	52.6±1.1	54.53±1.45		56.3±1.1	52.8±0.2
1006		3.0	2.31±0.13				2.39±0.13
1087	36±3	44**	36.7±0.5	46.25±1.10		39.6±0.8	37.6±0.3
1089.7*	5.7±1.4		6.10±0.21			6.42±0.13	5.8±0.3
1113	45±3	52	49.1±0.5	51.28±1.40		50.9±1.0	50.1±0.3
1213		4.8	5.13±0.18				5.07±0.15
1249		1.5	0.65±0.04				0.73±0.11
1408	71±3	82	75.9±1.8	80.78±2.10		80.7±1.6	77.8±0.3
1525		1.1	1.25±0.09				0.89±0.12

*) Aubin et al.

**) Sum of 1087 and 1089.7 keV γ rays

Table 2. Energies of the ^{152g}Eu photons below 500 keV (in keV)

Leder 3) et al.	Varnell 5) et al.	Aubin 6) et al.	Notea 7) et al.	Present work
39.52			39.5±0.2	39.69
45.4			45.2±0.2	45.17
121.79	121.8	121.78±0.03	121.9±0.1	121.84
244.7	244.7	244.66±0.03	244.75±0.08	244.63
296	295.9	295.97±0.07	295.8±0.1	295.98
344.4	344.2	344.31±0.03	344.44±0.09	344.32
367	367.6	367.80±0.07	367.8±0.2	367.76
411.2	410.9	411.13±0.05	411.3±0.2	411.06
444.2	443.8	443.98±0.05	444.2±0.2	443.94

I-C-8. Slow-Neutron Scattering by Light and Heavy Water

Y. Gotoh and H. Takahashi*

A full paper on this subject was published in the Nucl. Sci. & Eng. 45, (1971) 2, p. 126-140.

Since the model in which the water molecules form partially "ice-like" clusters explains the thermodynamic properties, the so-called itinerant oscillator model is applied to the motion of water molecules. The assumption is made that the atoms in a molecule receive stochastic forces from the neighboring molecules. The model of water with the stochastic force of which the correlation functions are delta-function and a simple exponential, is discussed.

* Brookhaven National Laboratory, Upton, L.I., New York 11973

By the model the generalized frequency distributions of light and heavy water are derived. The incoherent calculations of scattering laws of light and heavy water are compared with measurements. The model predicts well the total scattering cross section of light water, but the average cosine of scattering angle is slightly higher than the experiment. The further refinements in the model are discussed.

I-C-9. A Computational Method of Thermal Neutron Scattering Kernels for High Temperature Crystals

Y. Nakahara and H. Kadotani*

A full paper on this subject will be published in JAERI report with an abstract as follows:

An effective computational method of thermal neutron scattering kernels for high temperature crystals is established and a new computer code HIKER based on our computational scheme has been made available.

Important techniques in our method which take consideration of the high temperature characteristics of crystals are the following two approximations:

1) The Debye model is used for the low frequency part of the frequency distribution of crystal lattice vibrations. This makes it possible to perform the computation of the scattering law or the dynamical structure factor for the low frequency lattice modes analytically.

2) The Doppler approximation is used when the Debye-Waller factor for the high frequency part of the frequency distribution exceeds a certain limit (above which the good convergence of the Edgeworth series is violated).

* C. Itoh Electronic Computing Service Co., Ltd.

When the Debye-Waller factor is below the limit, the scattering law for the high frequency lattice modes is computed by the usual phonon expansion and Edgeworth series method. The total scattering law is obtained by convolving the two partial scattering laws for the low and high frequency lattice modes. The scattering kernel $\sigma(E_0, E)$ is obtained from the total scattering law by employing the interpolation over (κ, ε) and the Gaussian integration over the scattering angle.

We succeeded in reducing the computational time considerably. Our method has been proved to be very effective in obtaining the scattering kernels for high temperature crystals.

D. Japanese Nuclear Data Committee

I-D-1. Evaluation of the Total Neutron Cross Section of Carbon up to 2 MeV

K. Nishimura, S. Igarasi, T. Fuketa and S. Tanaka

The paper on this subject is submitted to JAERI Report with an abstract as follows:

Total neutron cross section of carbon has been evaluated in the energy range from 1 eV to 2 MeV. Fourth order polynomials of neutron energy are fitted to the collected experimental data by the method of least-squares. The assessment of the weight includes an account for the experimental errors of the individual data points, number of data points in individual experiment and a weight given to the measurement by the present authors. The difference between the experimental cross-section data obtained by time-of-flight method and those by direct-current-beam method, and non-uniformity of distribution of the data points over the neutron energy range are discussed. A recommended value of total neutron cross section of carbon is given as

$$\sigma_{nT}(E) = 4.699 - 3.061E + 1.069E^2 - 0.095E^3 - 0.026E^4,$$

where E is in MeV and σ_{nT} in barns. Uncertainty of the recommended value is estimated to be less than 2 to 3% in the energy region up to 1.8 MeV. The cross-section curve is compared with those of BNL 325, ENDF/B, KFK 750 and AWRE data files.

I-D-2. Analyses on the Total Neutron Cross Sections of Nuclei with Z = 33 to 73

S. Igarasi, M. Kawai, T. Nakagawa and K. Nishimura

Total neutron cross sections of nuclei with Z=33 to 73 have been analysed to look for systematics of the optical potential parameters in the energy range from 100 keV to 15 MeV. The set of potential parameters presented by Engelbrecht and Fiedeldy[1] is used for the analyses of the nuclei with $A \leq 140$. Agreement between experimental data and calculated value is good. For the nuclei with $A > 140$, automatic parameter search is made in order to find out a better set of the potential parameters. The analysis is now in progress.

Reference:

1) Engelbrecht and Fiedeldy: Ann. of Phys. 42 (1967) 262.

I-D-3. Compilation of Neutron Elastic and Inelastic Scattering Cross Section Data - Data of Pu, U, Ni, Fe, Cr, Na and O -

S. Igarasi and Members of sub-working group in JNDC

Elastic and inelastic scattering cross section data are collected and compiled by a sub-working group of Nuclear Data Information and Evaluation working group in JNDC. Data of Pu, U, Na and O are compiled and released in JAERI-memo[1]. Compilation of medium weight nuclei, Ni, Fe and Cr, are now in progress. These data will be used for nuclear data evaluation work.

References:

1) JAERI-memo 4160 (unpublished) Oct. 1970

2) JAERI-memo 4404 (") May 1971

3) JAERI-memo 4405 (") May 1971

I-D-4. NESTOR - Neutron Data Storage and Retrieval System

T. Nakagawa, S. Igarasi and the members of the Data Retrieval Working Group in JNDC

NESTOR has been prepared to handle the huge amount of numerical data hitherto collected at the Nuclear Data Laboratory, JAERI. Those data include the experimental neutron data most of which have been obtained from CCDN and the evaluated neutron data.

NESTOR is a rewritten system in FORTRAN IV from NEUDADA* which is written in PL/I, and some modifications have been and will be made to the system. Some specification of the NESTOR are as follows:

computer ...... FACOM 230-60

language ...... FORTRAN IV

input format

- tape ...... NEUDADA's internal expanded format
- card ...... NESTOR format

output format

- tape ...... NEUDADA's transmission format
  - " calculation format
  - " internal expanded format
- card ...... " calculation format
- list

* NEUDADA; NEUDADA system description (CCDN)

I-D-5. Bibliography for Thermal Neutron Scattering

The Thermalization Group, Japanese Nuclear Data Committee

The compilation and publication of the bibliography for thermal neutron scattering have been performed by the Thermalization Group of Japanese Nuclear Data Committee.

This bibliography contains references to the literature not only on measurements and calculations of thermal neutron scattering cross sections but also on the basic studies of lattice dynamics, and fluid and molecular dynamics in so far as it is concerned with the thermal neutron scattering.

The next publication of the bibliography consists of two lists, where references are classified by the computer. In the first list they are classified according to the last two digits of the year and the first two alphabetical letters of the last name of first author. In the second list they are classified according to the species of materials and indicated by the classification number in the first list.

At present the compilation of about twelve hundred references is in progress for the publication in the near future.

II. Kyoto University
Research Reactor Institute

II-1. Measurements of Average Cross Sections for Some Threshold Reactions (2)

I. Kimura, K. Kobayashi and T. Shibata

After papers on this subject were published[1][2], cross section measurements for some other threshold reactions have been successively carried out in the core of the Kyoto University Reactor, KUR and with a fission plate of enriched uranium.

Results for the $^{232}Th(n,2n)^{231}Th$ reaction is to be published soon[3]. The obtained value of the average cross section for this reaction is compared with the earlier data in Table 1.

The average fission cross section of ^{237}Np was measured by making use of the fission plate. The result is given in Table 2, which will be presented at the meeting of Atomic Energy Society of Japan, 3 ~ 5, October 1971.

The average cross sections for the $^{103}Rh(n,n')^{103m}Rh$ and $^{115}In(n,n')^{115m}In$ reactions were also measured with the fission plate and the results agree with the values obtained from the energy dependent cross sections by authors[4] within experimental error as shown in Table 3.

References:

1) Kimura, I., Kobayashi, K. and Shibata, T., "Measurements of Average Cross Sections for Some Threshold Reactions for Neutrons with Fission-type Reactor Spectrum" J. Nucl. Sci. Technol. 8 (1971) 59.

2) Kobayashi, K. and Kimura, I., "Measurement of Average Cross Section for the $^{232}Th(n,f)$ Reaction for the Fission-type Reactor Spectrum" Ann. Repts of Res. Reactor Inst., Kyoto Univ., 3 (1970) 84.

3) Kobayashi, K., Hashimoto, T. and Kimura, I., "Measurements of Average Cross Section for the $^{232}Th(n,2n)^{231}Th$ Reaction to Neutrons with Fission-type Reactor Spectrum and of Gamma-ray Intensities of ^{231}Th" J. Nucl. Sci. Technol. 8 (1971) (in print).

4) Kimura, I., Kobayashi, K. and Shibata, T., "Measurement of Cross Section for the $^{103}Rh(n,n')^{103m}Rh$ Reaction and Its Application to Fast Neutron Flux Measurements" J. Nucl. Sci. Technol. 6 (1969) 485.

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15) Köhler, W. and Knopf, K., Nukleonik 10 (1967) 181.

16) Bresesti, A. M., et al., Nucl. Sci. Eng. 40 (1970) 331.

17) Kanda, K., Chatani, H. and Shibata, T., Ann. Repts of Res. Reactor Inst., Kyoto Univ., Vol. 4 (1971) in print.

Table 1. Comparison of fission-averaged cross sections for $^{232}Th(n,2n)^{231}Th$ reaction.

Average cross section (mb)	Reference
12.5 ± 0.84	Present work, measured in the core of KUR
12.4 ± 0.6	Phillips' work[5], measured in the core of BEPO
13.1	Present calculation with the cross section in U-K library[6] and Leachman's fission spectrum[7]
14.7	Present calculation with the cross section obtained by Butler and Santry[8] and Leachman's fission spectrum
15.5	Present calculation with the cross section in U-K library and SAND-II fission spectrum[9]
17.4	Present calculation with the cross section obtained by Butler and Santry and SAND-II fission spectrum

Table 2. Comparison of fission-averaged cross sections for $^{237}Np(n,f)$ reaction.

Average cross section (barn)	Reference
1.33 ± 0.11	Present work, measured with a fission plate
1.323	Zijp's work[10]
1.460	Fabry's work[11]
1.367	Grundl's work[12]
1.32	Present calculation with the data by Grundl[13] and Leachman's fission spectrum
1.43	Present calculation with the data by Grundl and SAND-II fission spectrum[9]
1.17	Present calculation with the data by Davey[14] and Leachman's fission spectrum
1.28	Present calculation with the data by Davey and SAND-II fission spectrum

Table 3. Comparison of fission-averaged cross sections for $^{103}Rh(n,n')^{103m}Rh$ and $^{115}In(n,n')^{115m}In$ reactions.

$^{103}Rh(n,n')^{103m}Rh$	$^{115}In(n,n')^{115m}In$	Reference
560 ± 7	175 ± 2	Present
558 ± 32	177 ± 10	Kimura[1]
589	174	Fabry[11]
403 ± 40	181 ± 10	Köhler[15]
	177 ± 6	Bresesti[16]
566 ± 23	171 ± 5	Kanda[17]

III. Kyushu University

Department of Nuclear Engineering

III-1. Elastic and Inelastic Scattering of 14.1 MeV Neutrons by N^{14}

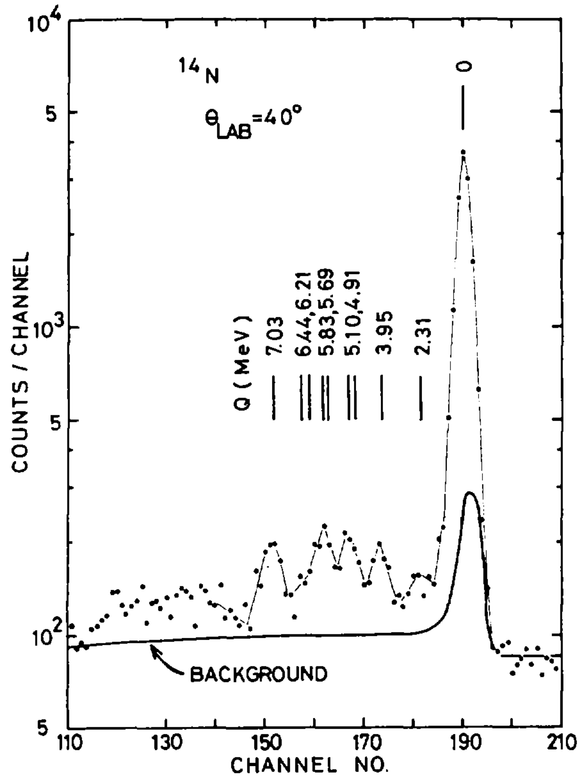
M. Hyakutake, H. Tawara, M. Matoba, M. Sonoda, A. Katase,

Y. Wakuta, and S. Nakamura

Elastic and inelastic scattering cross sections of 14.1 MeV neutrons by N^{14} have been measured in the angular range $10^{\circ} \leq \theta_{lab} \leq 160^{\circ}$ using an associated-particle time-of-flight spectrometer. This TOF spectrometer was improved for the time resolution and the reduction of background[1]. The nitrogen sample was of liquid and a dewar made of stainless steel was used. A TOF spectrum at $\theta_{lab} = 40^{\circ}$ and 2.5 m flight path is shown in Fig. 1.

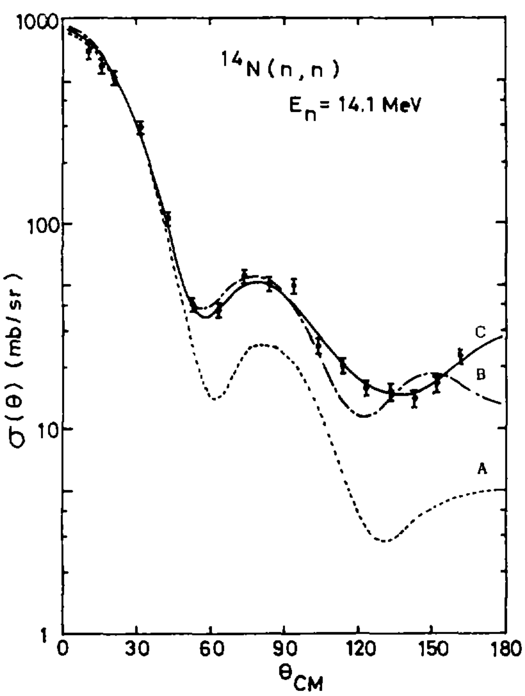
Angular distributions for four states (Q=0, -2.31, -3.95, -7.03 MeV) and three groups (Q=(-4.91, -5.10 MeV), (-5.69, -5.83 MeV), (-6.21, -6.44 MeV) were obtained. The experimental angular distribution for the elastic scattering is shown in Fig. 2. The results for the elastic scattering and 3.95 MeV state are in good agreement with previous TOF works[2].

These results were compared with the optical model predictions and the distorted wave theory. An automatic search program code "SEEK" was used for the optical model calculation. In Fig. 2 are also shown the results of the optical model calculation. The parameters for curve A is the ones of Bjorklund and Fernbach[3]. Curves B and C are the present results of four- and seven-parameter search, respectively.



^{14}N
θ_{LAB}=40°
Q (MeV)
7.03
6.44,6.21
5.83,5.69
5.10,4.91
3.95
2.31
0
COUNTS / CHANNEL
BACKGROUND
CHANNEL NO.

Fig. 1



^{14}N(n,n)
E_n= 14.1 MeV
A
B
C
σ(θ) (mb/sr)
θ_{CM}

Fig. 2

References:

1) M. Matoba et al., EANDC (J) 13L (1969) p. 33.
M. Hyakutake et al., Japan. J. appl. Phys., vol. 10, No. 8 (to be published).

2) R. W. Bauel et al., Nuclear Physics 47 (1963) 241;
R. W. Bauer et al., Nuclear Physics A93 (1967) 673.

3) F. Bjorklund and S. Fernbach, Phys. Rev. 109 (1958) 1295.

III-2. The Excitation Functions and Isomer Ratios for Neutron-Induced Reactions on ^{92}Mo and ^{90}Zr*

Y. Kanda

Absolute cross sections of the reactions $^{92}Mo(n,2n)^{91m,91g}Mo$, $^{92}Mo(n,p)^{92}Nb$ and $^{92}Mo(n,\alpha)^{89m,89g}Zr$, relative cross sections of the reaction $^{90}Zr(n,2n)^{89m}Zr$ and isomer ratios of $^{90}Zr(n,2n)$ have been measured in the neutron energy range of 13 - 15 MeV. The results for the (n,2n) reactions are in good agreement with those of the previous studies. The present results for the (n,p) and (n,α) reactions are in disagreement with the previous works. The experimental data are analysed by the statistical model to determine the level density parameter a, the moment of inertia $\mathcal{J}$ and the strength of γ-ray transition S_ℓ so as to reproduce simultaneously the experimental data on the excitation function and the isomer ratio in (n,2n) reaction. Accounts are taken of γ-ray competition, yrast level and experimental information on the excited levels of the residual nucleus in the (n,2n) reaction. The obtained values of a, $\mathcal{J}$ and S_ℓ are consistent with those deduced from other types of nuclear data and with general trends of the parameters against the mass number.

* To be published.

III-3. Photo-Fission Cross Sections of the Medium-Mass Nuclei

A. Katase, M. Matoba, Y. Kanda, M. Chijiya, M. Sonoda
Y. Wakuta, H. Tawara and M. Hyakutake

The photo-fission cross sections of Ho, Sm, Te, Sb, Sn, In, Ag, Ge, Cu and Au were measured for the energies of 1000, 600, 450 and 250 MeV. The experimental method was reported previously[1].

From the fission cross sections obtained taking the 1/E approximation of the bremsstrahlung spectrum, the nuclear fissilities have been determined for Ho, Sm, Te, Sb, Sn, In, Ag and Au. (Fig. 1)

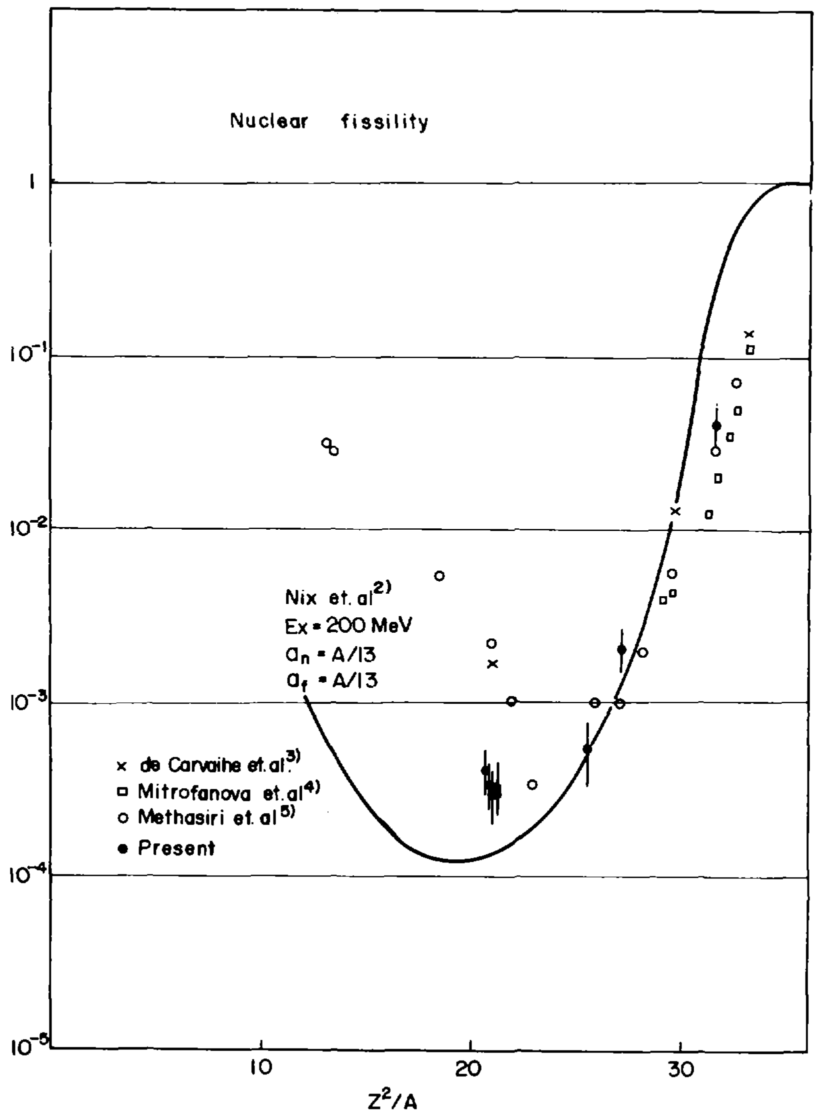


Fig. 1

References:

1) A. Katase et al., EANDC (J) AL (1969) P. 34, EANDC (J) AL (1970) P. 54.

2) J. R. Nix and S. Sassi, Nucl. Phys. 81 (1966) 61.

3) H. G. de Carvalho et al., Nucl. Phys. 53 (1964) 345.

4) A. V. Mitrofanova et al., Sov. Jour. of Nucl. Phys. 6 (1968) 512.

5) T. Methasiri and S. A. E. Johansson, LUNP 7016 (1970).

III-4. Long Range Alpha from Fission of ^{252}Cf

A. Katase, K. Tsuji, T. Katayama, Y. Kanda,

H. Yamamoto and Y. Yosida

The energy spectra of the light charged particles from fission of ^{252}Cf were measured at about 90^{o} to fission fragments.

Preliminary result is shown in Fig. 1. Our spectrum agrees with the results of Raisbeck and Thomas[1)]. A small difference at low energy may be due to the effects of tritons, which contaminate the present result, and our large solid angle.

Further measurements are now in progress.

References:

1) G. M. Raisbeck and T. D. Thomas: Phys. Rev. 172 (1968) 1272.

2) Z. Fraenkel: Phys. Rev. 156 (1967) 1283.

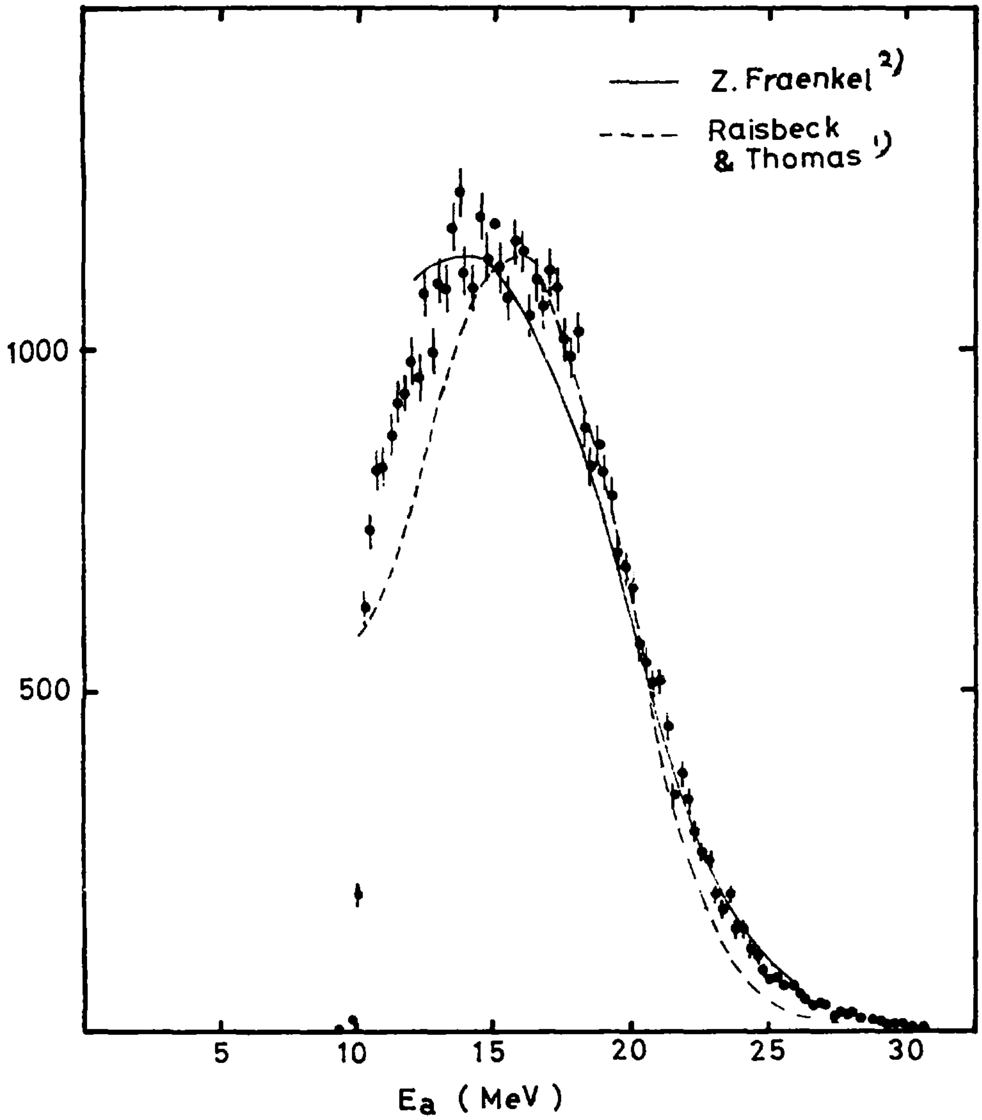


Fig. 1

IV. Nippon Atomic Industry Group Co., Ltd.
Nuclear Research Laboratory

IV-1. Lumped Capture Cross Sections of Fast Fission Products*

S. Iijima and T. Yoshida

This is a preliminary estimation of capture cross sections of lumped fission products for use of fast reactor, with the aim to determine the important fission product nuclides.

The methods of evaluation are as follows.

1) Fission yield data were taken from the evaluation by Meek and Ryder,[1)]
2) Only beta decay chains were considered,
3) 87 stable and long-lived nuclides were considered,
4) Capture cross section data were taken from the evaluation by Benzi and Reffo,[2)] and
5) For 10 nuclides not appearing in the data evaluated by Benzi and Reffo, capture cross sections were determined by eye-guide interpolation of their data.

Resulting lumped capture cross sections (per fission) for fissions from ^{235}U, ^{238}U, ^{239}Pu. and ^{241}Pu are shown in Fig. 1, together with the evaluated group cross sections by Abagyan et al.[3)] Through the course of present estimation it was noted that

1) the neglect of relatively short-lived nuclides in a chain will not cause a significant error in the "chain cross section", since the cross sections of even-odd nucleus and odd-even nucleus with fixed mass number are usually alike, and

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* The work was done as a part of the activities of Fast Fission Product Working Group, Japanese Nuclear Data Committee.

2) about and above 1 MeV, the capture cross sections of even-even nuclides are equally important as those of odd mass nuclides. More efforts of evaluation of capture cross sections are felt necessary in this energy range.

References:

1) Meek, M. E. and Ryder, B. F., APED-5398-A (1968)

2) Benzi, V. and Reffo, G., CCDN-NW/10 (Dec., 1969)

3) Group Constants for Nuclear Reactor Calculations, edited by I. I. Bondarenko, Constants Bureau, N.Y., 1964 (translation from Russian)

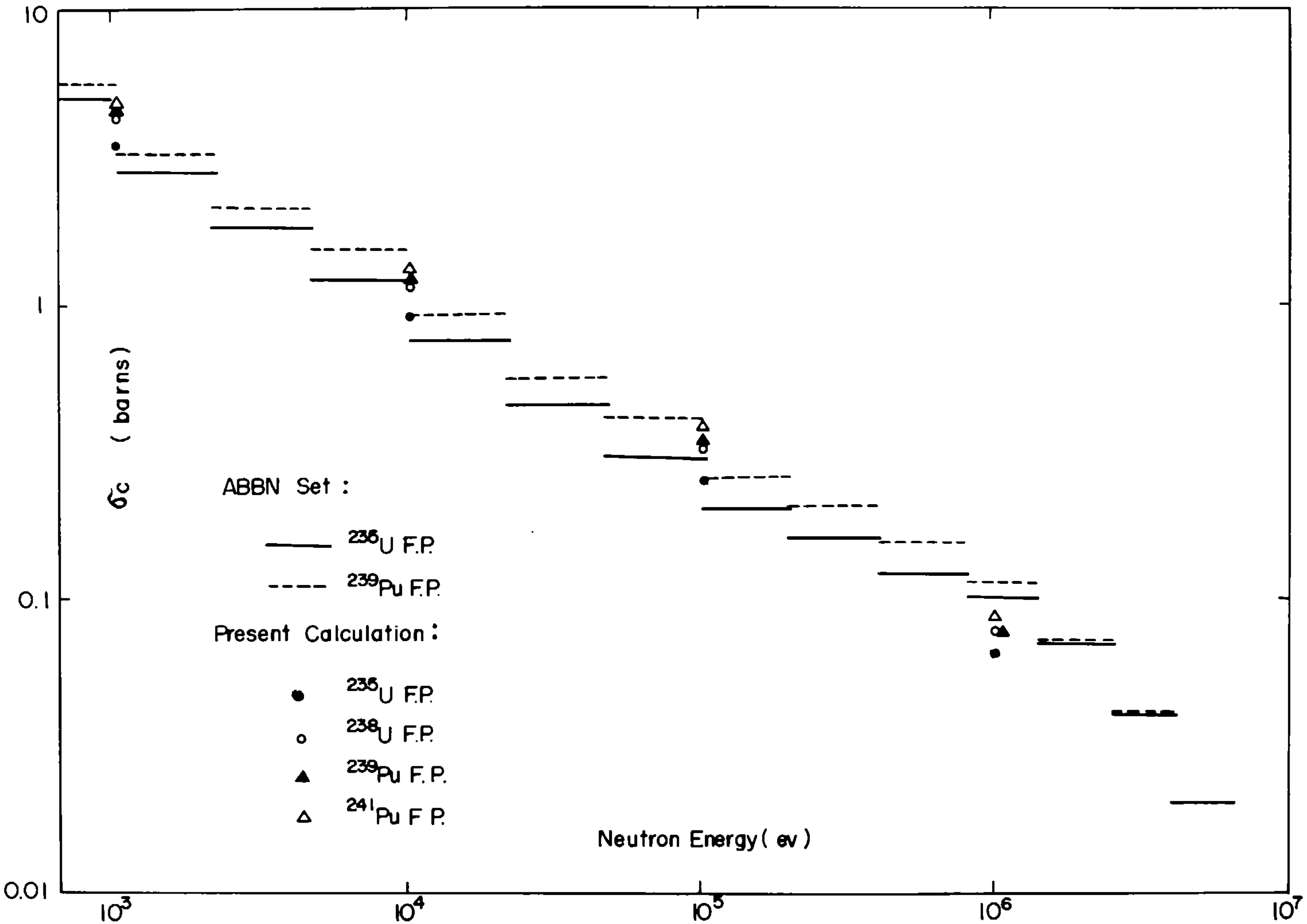

Fig. 1. Lumped Capture Cross Sections of Fast Fission Products for Neutron-Induced Fissions from ^{235}U. ^{238}U, ^{239}Pu, and ^{241}Pu.

V. Osaka University
Department of Physics

V-1. (N-Z) Dependence of (n, γ) Cross Sections

K. Matsuoka, I. Isomoto*, M. Sano, S. Igarasi**
and K. Nishimura**

The (n, γ) cross sections in low energy region decrease as the neutron excess (N-Z) of target nucleus increases, except for nuclei with magic neutron number. This trend is explained by taking account of the (N-Z) dependence of the neutron separation energy on the basis of statistical model. Detailed calculations are now in progress by the use of a computer code RACY.

* Present address: Computation Center, Osaka University.

** JAERI

VI. Tohoku University
Department of Nuclear Engineering

VI-1. Semi-empirical Treatment of Delayed Neutron Emission

S. Nakaya, S. Iwasaki, K. Sugiyama and E. Takekoshi*

A correlation between the delayed neutron emission probability (P_n) and the $Q_\beta - S_n$ value has been studied. A new semi-empirical formula is derived as follows,

$$\lambda_n \equiv P_n \cdot \lambda_\beta = C(Q_\beta - S_n)^m ,$$

where λ's are decay constants of neutron and beta-particle, C and m are adjustable parameters which are determined by using experimental data and a mass formula. This relation was not obtained on the basis of the combination of the usual β-decay theory and level density as proposed by Amiel et al.[2], but on the basis of the gross theory of beta-decay. Fig. 1 shows a correlation between the experimental values of λ_n and the values of $Q_\beta - B_n$ which are taken from Garvey's mass table[3].

The authors have also tried to predict the possible and prospective delayed neutron precursors and found a systematics of beta-decay half-lives.

References:

1) K. Takahashi and M. Yamada, Prog. Theor. Phys. 41 (1969) 1470
K. Takahashi and M. Yamada, "An approach to Delayed Neutron Emission with Gross Theory of β-decay" (unpublished note, 1969).

2) S. Amiel and H. Feldstein, Phys. Letters 31B (1970) 59.

3) G. T. Garvey, et al., Rev. Mod. Phy. 41 (1961) Supplement.

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* JAERI

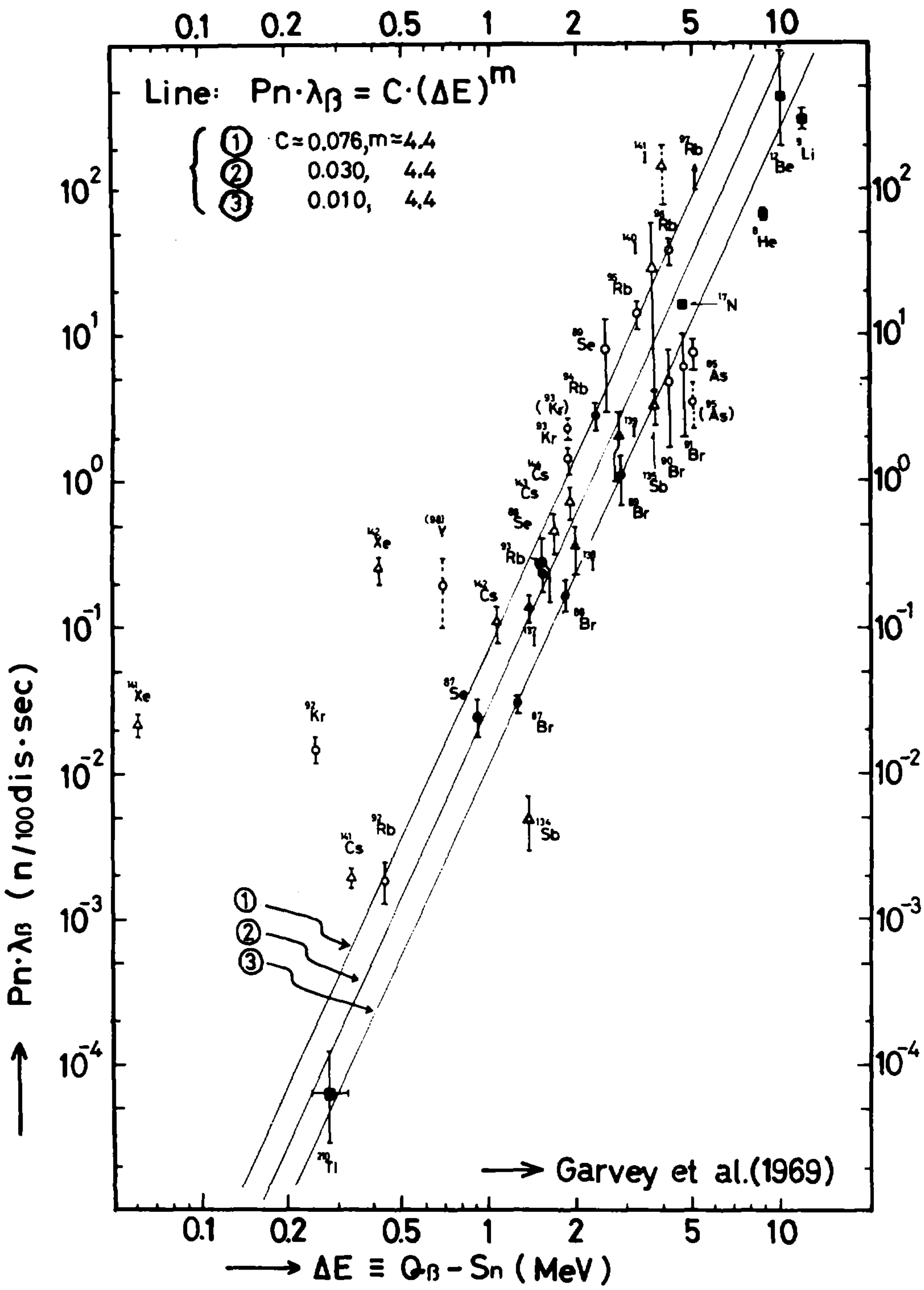

Fig. 1. λ_n as a function of $(Q_\beta - S_n)$

VI-2. Gamma-ray Spectrum and Damage of Ge(Li) Detector on the Irradiation of the Neutrons

S. Iwasaki, S. Itagaki, H. Matsuno and K. Sugiyama

Measurements of Gamma-ray spectra on the Ge(Li) detector during and after irradiation by the neutron of thermal, 2.5 and 14 MeV are performed for the study of the neutron inelastic scattering from several materials using the Ge(Li) detector and the radiation damage of the detector. Preliminary results show somewhat different spectra with previous measurements[1)] by K. C. Chang et al. who carried out for 1.75, 2.13, 2.55 MeV neutrons.

References:

1) K. C. Chang, A. Mittler, J. D. Brandenberger and M. T. McEllistrem, Phys. Rev. C2 (1970) 139.

VII. University of Tokyo
Institute of Physics, College of General Education

VII-1. Scattering of Nucleons by ^{12}C and the Structures of ^{13}N and ^{13}C

O. Mikoshiba*, T. Terasawa and M. Tanifuji**

A paper on this subject was published in Nuclear Phys. A168 (1971) 417.

Scattering of protons and neutrons by ^{12}C has been investigated by the coupled-channel method in collective models for ^{12}C nucleus, paying particular attention to their resonance features. The elastic channel and the inelastic channel to the first 2^+ state have been coupled with each other. Weak spin-spin and ℓ^2 -dependent interactions have been taken into account as the correction to the optical potential. We calculated phase shifts, cross sections and polarizations of elastic scattering for both the proton and the neutron, and total cross sections of inelastic scattering to the $^{12}C^*$ (2^+, 4.43 MeV) state for the proton, up to E_p = 8 MeV and E_n = 4 MeV.

Satisfactory fits to the data have been obtained by using the rotational model with large deformation of negative sign, $\beta_2 \simeq -0.5$, and the following generalized optical potential:

$$v(r,\theta,\phi) = -v_c f(r) + v_{so}(\sigma\cdot\ell)\frac{\lambda^2_\pi}{r}\frac{d}{dr}f(r) + v_{coul} ,$$

where

$$v_c = v_o - a_E E_n + (\sigma\cdot I)v_{\sigma I} + (\ell\cdot\ell)v_{\ell\ell} ,$$

$$f(r) = [1 + \exp(r-R)/a]^{-1}$$

* Technology Science University of Tokyo

** Hosei University

and

$$R = R_0[1 + \beta_2 Y_{20}(\theta)]$$

The potential parameters are

V_o = 54.37 MeV, V_{so} = 6.5 MeV, $V_{\sigma I}$ = 0.37 MeV, V_{ll} = -0.44 MeV,

a_E = 0.26, r_o = 1.25 fm and a = 0.65 fm.

An example of the fits to the data is shown in Fig. 1, where the phase shifts of the even parity partial waves for n + ^{12}C scattering are compared between the calculated and the empirical with good agreements.

As to the collective model for ^{12}C, neither the vibrational model nor the rotational model with small β_2 nor positive β_2 were successful to reproduce all experimental data consistently.

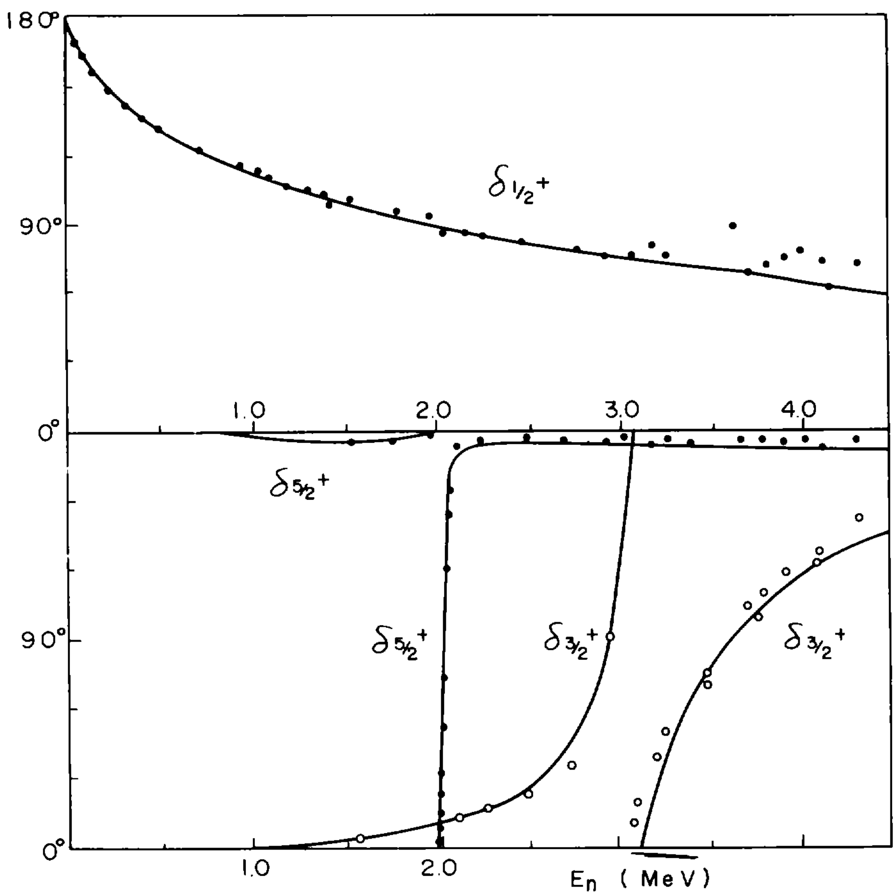

Fig. 1

VIII. Waseda University
Department of Applied Physics

VIII-1. Delayed Neutron Emission Probability*

K. Takahashi**

Recently, an empirical systematics of the delayed neutron emission rate λ_n[1] (instead of P_n[2]) against $\Delta E = Q_\beta - S_n$ was suggested. Strength functions of allowed and 1-st-forbidden β-decays of the precursors are calculated with the gross theory.[3] The strengths are less energy-dependent than those of Pappas et al.[4] We get λ_n, ignoring the γ-competition for simplicity.

Satisfactory results are obtained for λ_n. The systematics can be theoretically explained at relatively low ΔE. The results with further refinements will be reported elsewhere.

References:

1) E. Takekoshi et al., private communication (1971).
2) S. Amiel and H. Feldstein, Phys. Letters 31B (1970) 59.
3) K. Takahashi and M. Yamada, Prog. Theor. Phys. 41 (1969) 1470.
   S. I. Koyama, K. Takahashi and M. Yamada, Prog. Theor. Phys. 44 (1970) 663.
   M. Yamada, K. Takahashi and S. I. Koyama, CERN 70-30 (1970) p. 397.
   K. Takahashi, Prog. Theor. Phys. 45 (1971) 1466.
4) T. Jahnsen, A. C. Pappas and T. Tunaal, "Delayed Fission Neutrons" (IAEA, Vienna, 1968) p. 35.

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* A part of the report at the Tokyo meeting of the Physical Society of Japan (June, 1971)

** Postdoctral Fellow of the Japan Society for the Promotion of Science