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NOT FOR PUBLICATION

INDC(JAP)-28"L"

NEANDC(J)-42"L"

PROGRESS REPORT

(July 1974 to June 1975 inclusive)

September 1975

Editors

T. Fuketa, T. Tamura and S. Kikuchi

Japanese Nuclear Data Committee

Japan Atomic Energy Research Institute

Tokai Research Establishment

Tokai-mura, Ibaraki-ken, Japan

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

This edition covers a period of July 1, 1974 to June 30, 1975. The information herein contained is of a nature of "Private Communication". No data contained in this report should be quoted without the author's permission.

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(H. Amano, A. Asami, T. Fuketa, Y. Goto, K. Harada, M. Hirata, J. Hirota, H. Kuroi, S. Miyasaka, H. Natsume, S. Tsujimura, K. Tsukada, K. Ueno, et al.)

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ELEMENT S A	QUANTITY	LAB	ENERGY(EV) MIN	MAX	TYPE	DOCUMENTATION REF VOL PAGE	DATE	COMMENTS
H 001	Total	KTO	2.4+4		Expt Prog	NEANDC(J)42L25	9/75	FUJITA+.LINAC, SIG=17.740+-0.023 BARN
LI 006	Diffelastic	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
LI 006	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
LI 007	Diff Elastic	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
LI 007	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
BE	Thermal Scat	KTO	2.0-3	3.0-1	Expt Prog	NEANDC(J)42L23	9/75	KANDA+.TOTAL CS.TEMPERATURE EFFECT
BE 009	Diff Elastic	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(75)407
BE 009	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
B 010	Diff Elastic	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
B 010	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
B 011	Diff Elastic	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
B 011	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L38	9/75	HYAKUTAKE+.PUBLISHED IN NST11(74)407
O 016	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS.NDG
F 019	(n,2n)	JAE	1.1+7	2.0+7	Eval Prog	NEANDC(J)42L17	9/75	SUGI+.STAT-MDL.NORM AT 14.7 MEV DATA
NA 023	Evalutaion	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS.NDG
MG 024	(n,p)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=1.36+-0.065 MB
AL 027	(n,p)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=3.64+-0.17 MB
S 032	Diff Elastic	JAE	2.2+7		Expt Prog	NEANDC(J)42L 6	9/75	YAMANOUTI+.CFD C COUPLED CHANNEL MDL
S 032	Diff Inelast	JAE	2.2+7		Expt prog	NEANDC(J)42L 6	9/75	YAMANOUTI+.CRD C COURLED CHANNEL MDL
TI 046	(n,p)	KTO	PILE		Expt prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=10.9+-0.59 MB
TI 047	(n,p)	KTO	PILE		Expt prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=18.9+-0.87 MB
TI 048	(n,p)	KTO	PILE		Expt prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.256+-0.013 MB
V 051	(n,p)	KTO	PILE		Expt prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.456+-0.023 MB
V 051	(n,α)	KTO	PILE		Expt prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.0197+-0.0012 MB
CR	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS.NDG
FE	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS.NDG
FE	Diff Elastic	KYU	1.4+7		Expt Prog	NEANDC(J)42L39	9/75	HYAKUTAKE+.PUBLISHED IN JPJ38(75)606
FE	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L39	9/75	HYAKUTAKE+.PUBLISHED IN JPJ38(75)606
FE	Diff Inelast	KYU	1.4+7		Expt Prog	NEANDC(J)42L43	9/75	IRIE+.PUBLISHED IN JPJ 37(74)1461
CO 059	(n,α)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.131+0.0061 MB
NI	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS. NDG
NI 058	(n,2n)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=5.34+-.25MICROB
CU 063	(n,2n)	KTO	PILE		Expt prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.116+-0.016 MB
CU 063	(n,α)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.484+-0.0034 MB
ZN 064	(n,p)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=30.9+2.1 MB
ZN 066	(n,p)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.534+-0.038 MB
ZR 090	(n,2n)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.229+-0.015 MB

ELEMENT S A	QUANTITY	LAB	NENRGY(EV) MIN	MAX	TYPE	DOCUMENTATION REF VOL PAGE	DATE	COMMENTS
ZR 093	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
NB 093	Diff Inelast	KYU	1.4+7		Theo Prog	NEANDC(J)42L40	9/75	IRIE+.ENERGY SPECTRUM SHOWS PRE-COMP
NB 093	(n,2n)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.ISOMER SIG GIVEN
NB 093	(n,γ)	TIT	2.4+4		Expt Prog	NEANDC(J)42L56	9/75	YAMAMURO+.LINAC,FE-Filter.SIG=0.33B
NB 093	(n,α)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.ISOMER SIG GIVEN
MO 092	(n,p)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.ISOMER SIG GIVEN
MO 092	(n,α)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=0.0381+-.0024MB
MO 094	Inelastic γ	JAE	1.5+6	4.0+6	Expt Prog	NEANDC(J)42L 5	9/75	SUGIYAMA+.1.74MEV LVL ASSIGNED AS 0+
MO 095	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
MO 096	Diff Elastic	JAE	5.1+6	8.0+6	Expt Prog	NEANDC(J)42L 5	9/75	TANAKA+.VDG,TOF.NDG
MO 096	Diff Inelast	JAE	5.1+6	8.0+6	Expt Prog	NEANDC(J)42L 5	9/75	TANAKA+.VDG,TOF.NDG
MO 097	Evaluation	JAE	THR	1.5+7	Eval Plog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
TC 099	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
RU 101	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
RU 102	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
RU 104	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
RU 106	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
RH 103	Evlauation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
PD 105	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
PD 107	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
AG	(n,γ)	TIT	2.4+4		Expt Prog	NEANDC(J)42L56	9/75	YAMAMUTO+.LINAC,FE-FILTER.SIG=1.10
AG 109	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTRURE-CS AT 30KEV IN TABLE
IN	(n,p)	KYU	1.4+7		Expt Prog	NEANDC(J)42L43	9/75	NIIDOME+.PUBLISHED IN NP A245(75)509
I 127	(n,γ)	TIT	2.4+4		Expt Prog	NEANDC(J)42L56	9/75	YAMAMUTO+.LINAC,FE-FILTER.SIG=0.76B
I 129	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
XE 131	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
CS 133	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
CS 135	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
CS 137	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
CE 144	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
ND 142	(n,2n)	KYU	1.5+7		Expt Prog	NEANDC(J)42L45	9/75	KUMABE+.ACTIVATION.SIG=1675+-160 MB
ND 143	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
ND 144	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
ND 145	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
ND 146	(n,α)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST.SIG=4.42+-0.47 MB
ND 148	(n,2n)	KYU	1.5+7		Expt Prog	NEANDC(J)42L45	9/75	KUMABE+.ACTIVATION,SIG=1789+-147 MB
ND 150	(n,2n)	KYU	1.5+7		Expt Prog	NEANDC(J)42L45	9/75	KUMABE+.ACTIVATION,SIG=1720+-128 MB
PM 147	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE

ELEMENT S A	QUANTITY	LAB	ENERGY(EV)		TYPE	DOVUMENTATION REF LOV PAGE	DATA	COMMENTS
SM 147	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
SM 149	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
SM 150	(n,p)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST,SIG=7.91+-1.01 MB
SM 151	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
SM 152	(n,α)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST.SIG=2.81+-0.42 MB
SM 154	(n,2n)	KYU	1.5+7		Expt Prog	NEANDC(J)42L45	9/75	KUMABE+.ACTIVATION,SIG=2010+-137 MB
EU 151	(n,γ)	JAE		5.0+7	Expt Prog	NEANDC(J)42L 3	9/75	MIZUNOTO+.LINAC,TOF,LIQ-SCINTI. NDG
EU 152	(n,γ)	JAE		5.0+7	Expt Prog	NEANDC(J)42L 3	9/75	MIZUNOTO+.LINAC,TOF,LIQ-SCINTI. NDG
EU 153	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
EU 155	Evaluation	JAE	THR	1.5+7	Eval Prog	NEANDC(J)42L14	9/75	IIJIMA+.CAPTURE-CS AT 30KEV IN TABLE
GD 160	(n,2n)	KYU	1.5+7		Expt Prog	NEANDC(J)42L45	9/75	KUMABE+.ACTIVATION,SIG=2173+-152 MB
HO 165	(n,γ)	TIT	2.4+4		Expt Prog	NEANDC(J)42L56	9/75	YAMAMURO+.LINAC,FE-FILTER.SIG=1.26B
YB 173	(n,p)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST.SIG=13.5+-2.8 MB
YB 174	(n,α)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST.SIG=1.22+-0.23 MB
YB 176	(n,2n)	KYU	1.5+7		Expt Prog	NEANDC(J)42L45	9/75	KUMABE+.ACTIVATION.SIG=2226+-152 MB
LU 175	(n,p)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST.SIG=18.5+-2.2 MB
LU 176	(n,α)	KYU	1.5+7		Expt Prog	NEANDC(J)42L44	9/75	SATO+.TBP IN NST.SIG=2.30+-0.57 MB
TA 181	Evaluation	JAE		1.5+7	Eval Prog	ENANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS.NDG
W	Elastic	JAE			Expt Prog	NEANDC(J)42L 3	9/75	OHKUBO.LINAC.NDG.PUBL IN JAERI-M6034
AU 197	(n,γ)	TIT	2.4+4		Expt Prog	NEANDC(J)42L56	9/75	YAMAMURO+.LINAC,FE-FILTER.SIG=0.68B
TH 232	Total	KTO	2.4+4		Expt Prog	NEANDC(J)42L28	9/75	KOBAYASHI+.LINAC,FE-FILT.SIG IN FIG
TH 232	Fission	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.SIG TO BA140 GIVN
U	Delayd Neuts	OSA			Expt Prog	NEANDC(J)42L51	9/75	JUKUDA.8 SHOULDERS IN N-SPECTRUN
U 235	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATUNOBU+.WORK IN PROGRESS.NDG
U 235	Evaluation	JAP	1.0+3	1.5+7	Eval Prog	NEANDC(J)42L11	9/75	MATSUNOBU. PRESENT STATUS DISCUSSED
U 238	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS.NDG
U 238	Reson Params	JAE	2.0+1	5.0+3	Expt Prog	NEANDC(J)42L 2	9/75	NAKAJIMA+.WN.PUBLISHED IN 75WASH. NDG
U 238	(n,2n)	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.S=15.7+-0.80 MB
U 238	Fission	KTO	PILE		Expt Prog	NEANDC(J)42L31	9/75	KOBAYASHI+.REACTOR.SIG TO BA140 GIVEN
U 238	(n,γ)	TIT	3.0+6	2.0+7	Theo Prog	NEANDC(J)42L57	9/75	KITAZAWA+.FIGS.DIRECT+COLLECTIVE MDL
U 238	(n,γ)	TIT	2.4+4		Expt Prog	NEANDC(J)42L56	9/75	YAMAMURO+.LINAC,FE-FILTER.SIG=0.50B
NP 237	(n,2n)	KTO	9.6+6	1.4+7	Expt Prog	NEANDC(J)42L26	9/75	NISHI+.NDG,C-W.ACTIVATION.SIGS GIVEN
PU 239	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS. NDG
PU 239	Reson Params	JAE			Revw Prog	NEANDC(J)42L16	9/75	YOSHIDA.PUBLISHED IN JAERI-M5979
PU 240	Evaluation	JAE		1.5+7	Eval Prog	NEANDC(J)42L 9	9/75	MATSUNOBU+.WORK IN PROGRESS. NDG
AM 241	Evaluation	JAE	1.0+3	2.0+7	Eval Prog	NEANDC(J)42L13	9/75	IGARASI.PUBLISHED IN JAERI-M6271
CF 252	Fiss Prod γ	KYU			Expt Prog	NEANDC(J)42L47	9/75	YOSHIDA+.SPONTANEOUS FISSION.NDG.
MANY	Reson Params	JAE			Theo Prog	NEANDC(J)42L 7	9/75	IDENO.PUBLISED IN JPJ 37(74)581

I. HIROSHIMA UNIVERSITY

Department of Physics, Fuculty of Science

I-1 Evaluation of Gamma-Ray Intensities

Y. Yoshizawa, H. Inoue, M. Hoshi and K. Shizuma

Relative intensities and intensities per decay of gamma rays in the decays of five nuclides, ^{22}Na, ^{60}Co, ^{95}Zr, ^{106}Ru and ^{134}Cs were evaluated. Recommended values are shown in the table.

Nuclide	Gamma-Ray Energy (keV)	Relative intensity	Intensity per decay (%)
^{22}Na	511	178.6 ±0.1	178.5 ±0.1
	1275	100.00 ±0.001	99.94 ±0.02
^{60}Co	1173	99.91 ±0.02	99.89 ±0.02
	1332	100.000±0.001	99.983±0.005
^{95}Zr	724	80.63 ±0.78	44.04 ±0.24
	757	100	54.62 ±0.24
^{106}Ru	512	100	20.45 ±0.58
	616	3.66 ±0.23	0.749±0.051
	622	48.3 ±1.2	9.88 ±0.32
	873	2.107±0.066	0.431±0.018
	1050	7.39 ±0.23	1.511±0.064
	1128	1.950±0.066	0.400±0.018
	1562	0.773±0.032	0.158±0.008
^{134}Cs	475	1.56 ±0.06	1.52 ±0.08
	563	8.88 ±0.29	8.48 ±0.33
	569	15.7 ±0.5	12.29 ±0.66
	605	100.0 ±3.2	97.50 ±0.07
	796	89.1 ±2.7	85.08 ±0.42
	802	9.03 ±0.33	8.81 ±0.43
	1038	1.04 ±0.04	1.01 ±0.05
	1168	1.97 ±0.04	1.92 ±0.07
	1365	3.36 ±0.10	3.28 ±0.14

II. JAPAN ATOMIC ENERGY RESEARCH INSTITUTE

A. Linac Laboratory

II-A-1 Neutron Resonance Parameters of ^{238}U

Y. Nakajima, A. Asami, M. Mizumoto, T. Fuketa and H. Takekoshi*

The paper on this subject was presented at the Conference on Nuclear Cross Section and Technology held at Washington, USA in March, 1975 with an abstract as follows.

Neutron transmission measurements on natural U samples were performed in the energy region from 20 eV up to 30 keV on a 190-m flight path of the JAERI 120-MeV linac neutron time-of-flight spectrometer. Samples were all metallic slabs with three thicknesses of 0.00725, 0.0144 and 0.0236 atoms/barn, respectively. One of them was cooled down to 77° K to reduce Doppler broadening. The best nominal resolution of the measurements was 0.3 nsec/m. A special attention has been paid to determine the background, because the shape of the background was found to depend on the thickness of the sample in the beam. Resonance paremeters Γn^0 are obtained in the energy region up to about 5 keV with the Atta-Harvey area-analysis program. Results are compared with currently available experimental data.

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II-A-2 Neutron Capture Cross Sections of ^{151}Eu and ^{153}Eu

M. Mizumoto, A. Asami, Y. Nakajima, Y. Kawarasaki, T. Fuketa and H. Takekoshi*

Average capture cross sections of ^{151}Eu and ^{153}Eu were measured by a large liquid scintillation detector at a 52 m flight path.

The separated isotopes were borrowed from ORNL Pool of USA and two kinds of sample, about 0.36 g/cm^2 and 0.54 g/cm^2 in thickness, were measured on ^{151}Eu and ^{153}Eu, respectively. The energy region covered in the measurements was up to 50 keV with a resolution of 2 nsec/m. A ^6Li glass detector was used as a neutron flux detector.

The analysis of the data is now in progress.

II-A-3 Multiple Scattering of Neutrons Impinging on Thick Materials in the Resonance Energy Region

Makio Ohkubo

The paper on this subject was published in a report, JAERI-M 6034 with an abstract as follows.

A multiple scattering effect on neutron capture and scattering yields was measured for tungsten plates of several thicknesses in the resonance energy region with a ^6Li - ^7Li pair glass scintillator. Observed capture and scattering data were compared with the results obtained by the Monte-Carlo calculations. At resonance energies, the capture yields show peaks for thin samples, whereas they show dips for thick samples. The reason for these complicated features are interpreted by investigating the distributions of neutron path length in the samples. A new method of $\Gamma n/\Gamma$ determination, which is essentially insensitive to the sample thickness, is discussed.

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II-A-4 Photoexcitation of Sm- and W- Isotope Levels

Y. Kawarasaki

After a surveying experiment[1] in search of the photoexcitable elements by neutron capture γ rays in vanadium, measurements were undertaken succeedingly on nuclear resonance scattering from Sm- and W-element.

The energies of the resonance levels both in Sm and W are the same and are determined to be 6519 keV. The scattered γ-ray spectra from both elements show evidently the existence of the inelastic γ-rays to the first excited states of the ground-state rotational bands. Their relative intensities are estimated to be as strong as or stronger than those of the elastic lines. (This is referred as "Nuclear Raman Effect".) The spins of the resonance levels and the excited levels are determined to be 1 and 2, respectively, from the angular distribution measurement of the scattered γ-rays. The isotopes responsible for these resonance scatterings are identified to be ^{154}Sm and ^{186}W. Further experimentation and analysis are now in progress in order to decide the level widths and to construct the level schemes.

Reference : 1) Y. Kawarasaki, J. Phys. Soc. Japan 36 (1974) 907

B. Nuclear Physics Laboratory

II-B-1 Fast Neutron Scattering from ^{96}Mo

S. Tanaka and Y. Yamanouti

The angular distributions of neutrons scattered elastically and inelastically from ^{96}Mo were measured in the energy range of 5.1 to 8.0 MeV with about 1-MeV steps. The measurement was made in the angular region 25° - 150° by using a multi-angle TOF spectrometer with four detectors and flight paths of 8 m. The ^{96}Mo sample was of a form of metalic powder packed in an aluminium cylinder of 3.5 cm diameter and 6.5 cm length.

Data analysis is now in progress.

II-B-2 Study of ^{94}Mo through the (n,n'γ) Reaction

Y. Sugiyama and S. Kikuchi

The ^{94}Mo (n,n'γ) reaction has been studied in the neutron energy range 1.5-4.0 MeV. Neutron inelastic scattering cross sections for levels up to 2.6 MeV of excitation have been measured from 1.5 to 3.0 MeV. The results have been analyzed by the opitical-statistical and the coupled-channels theories, and values of the opitical-potential parameters have been determined. The 1.74 MeV level has been observed and has been assigned to be 0^+. Most of the branching ratios and the mixing ratios for the γ-rays deexciting the levels below the 3.5 MeV of excitation have also been obtained.

The authors are greatly indebted to EANDC and US AEC for the use of a ^{94}Mo sample in the ORNL pool.

II-B-3

Coupled-channel analysis of the fast neutron scattering from ^{32}S

Y. Yamanouti and S. Tanaka

The elastic and inelastic scattering of 21.5 MeV neutrons from ^{32}S were analyzed in terms of the optical-model and the coupled-channel theory. Vibrational-model calculations were carried out in two independent calculations coupling as $(0^+ - 2_1^+ - 2_2^+ - 4_2^+)$ and $(0^+ - 2_1^+ - 3_1^-)$, where the subscript index labels the number of phonons. The contribution of the compound process was estimated using the Hauser-Feshbach formalism. Experimental data and the results of the coupled-channel calculations for the lowest 0^+, 2^+, 2^++4^+, and 3^- states in ^{32}S are shown in Fig.1. The optical and deformation parameters used in the calculations were as follows: $V = 42.48$ MeV, $W_D = 8.0$ MeV, $V_{so} = 5.5$ MeV, $a = 0.619$ fm, $b = 0.439$ fm, $a_{so} = 0.65$ fm, $r = 1.259$ fm, $r_D = 1.262$ fm, $r_{so} = 1.25$ fm,

$(0^+ - 2_1^+ - 2_2^+ - 4_2^+)$; $\beta_{02} = 0.286$, $\beta_{22} = 0.286$, $\beta_{02}' = 0.286$,
$\beta_{24} = 0.200$, $\beta_{04}' = 0.240$, $\beta_{02}'' = 0.150$,
$\beta_{04}'' = 0.180$

$(0^+ - 2_1^+ - 3_1^-)$; $\beta_2 = 0.3$, $\beta_3 = 0.36$

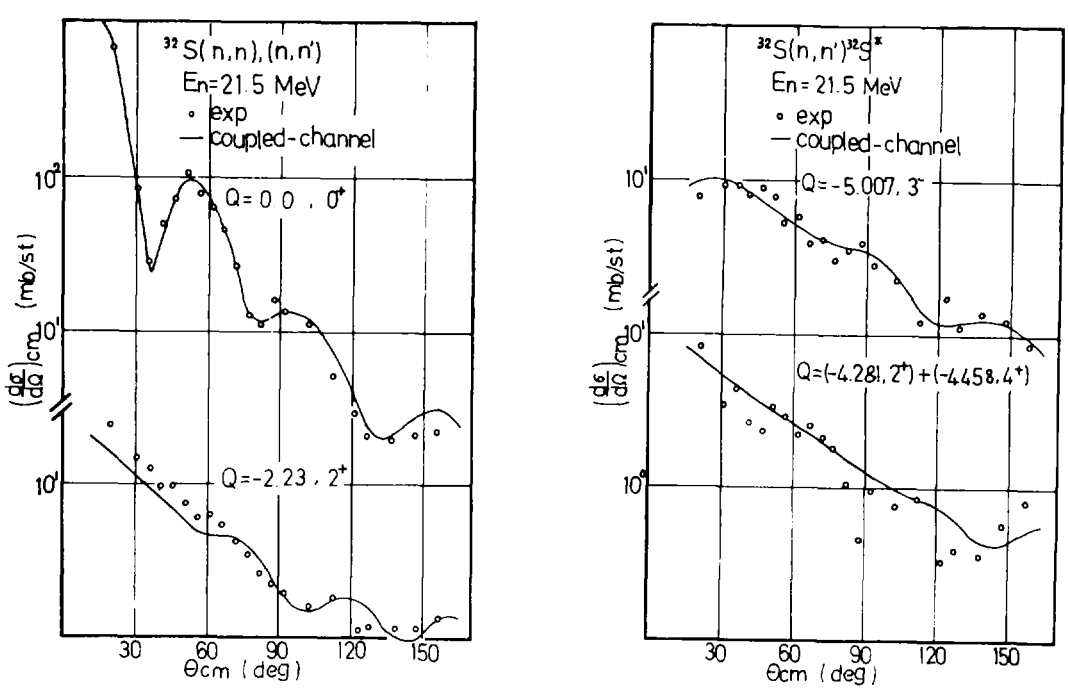

Fig.1

II-B-4

Nonstatistical Behaviours of the Level Spacing Distributions in Neutron Resonances

Kazumi IDENO

The paper on this subject is published in "Journal of the Physical Society of Japan" 37 (1974) 581". The abstract of this study is as follows:

Correlations of the level spacings in neutron resonances are analyzed with the method proposed by Ideno and Ohkubo. Periodic structures in the level spacing distributions are found in many nuclei. It is also found that there are coincidences among these periodicities and that there are a number of cases in which multiple relations are observed among them. The origin of the periodicities is discussed.

C. Nuclear Data Laboratory and Japanese Nuclear Data Committee

II-C-1

On Compilation of Japanese Evaluated Nuclear Data Library

----- Version - 1 (JENDL-1) -----

JENDL-1 Compilation Group

Survey of existing evaluated nuclear data had been carried out for H, He, Li-6, B, C, O, Na, Al, Ta, Fe, Ni, Cr, Mn, Cu, Mo, Si, Th-232, Pa-233, U-234, U-235, U-238, Np-239, Pu-239, Pu-240, Pu-241, Am-241 and some fission product nuclides, last financial year.

Compilation Group on JENDL-1 has started to select the suitable data and to compile them. Since the selected data do not necessarily cover the whole energy range (below 15 MeV), theoretical calculations have been performed to interpolate or estimate the data.

This compilation work will be finished at the end of this financial year.

II-C-2 Activity of the Nuclear Data Evaluation Working Group

H. Matsunobu and other members

The object of this group is to prepare for the evaluated nuclear data which are required for fast reactor design. This group is composed of three sub-working groups which take charge of the following tasks respectively.

1) Evaluation of the nuclear data for heavy nuclides

In this sub-working group, evaluation works of the nuclear data for ^{235}U, ^{239}Pu, and ^{240}Pu have been performed in the energy range from 1 keV to 15 MeV.

Evaluation of the total cross section σ_t and prompt neutron number per fission ν_p for ^{239}Pu was completed recently. The evaluated value of σ_t was given by three polynomial functions of neutron energy. The coefficients of these polynomial functions were determined by fitting to the adopted experimental data. The energy intervals of these functions are 1 $\sim$ 800 keV, 800 keV $\sim$ 2 MeV, and 2 $\sim$ 15 MeV. The evaluated value of ν_p was also given by two polynomial functions. The energy point connecting these functions is at 1.5 MeV.

On evaluation of the nuclear data for ^{240}Pu, most of the work was completed last year. The fission cross sections was evaluated on the basis of the compiled experimental data. The experimental data of other quantities except fission are very poor or do not exist. Accordingly, evaluation of total cross section, capture cross section, elastic and inelastic scattering cross sections was done by using theoretical calculation based on the optical model and statistical theory, and similarity to the cross sections of ^{238}U. The formula of Pearlstein[1)] and cross sections of ^{238}U were used in evaluation of (n,2n) and (n,3n) cross sections. The results of evaluation for ^{240}Pu were reported at the Atomic Energy Society of Japan held in November 1974.

At present, some calculations are in progress in order to obtain the Legendre expansion coefficients of $d\sigma el/d\Omega$, and the excitation functions to each excited level in inelastic scattering. Evaluation of the nuclear data for ^{235}U is described in the following section.

2) Compilation of the resonance parameters of heavy nuclides

Compilation of the resonance parameters of ^{239}Pu has been completed and published[2]. Those of ^{235}U, ^{238}U and ^{240}Pu are in the final stage and shortly to be submitted for publication in JAERI-M report.

3) Compilation and analysis of the nuclear data for light and medium-heavy nuclides

Compilation work of the nuclear data for O, Na, Cr, Fe, Ni, and Ta which are indispensable for fast reactor design was almost completed. The compiled experimental data for Fe, Ni, and Ta were plotted in graph using SPLINT[3] code, and compared with the compiled evaluated data. Besides data compilation, total, elastic and inelastic scattering cross sections and angular differential elastic scattering cross section for ^{56}Fe were calculated using ELIESE-3[4] code and the optical potential parameters of Engelbrecht-Fiedeldy[5]. As the results of parameter search, it was found that a good agreement between the calculated cross section and the experimental data was obtained over the wide energy range by a slight modification of the Engelbrecht-Fiedeldy's parameters.

References

1) S. Pearlstein : NSE 23, 238 (1965)
2) T. Yoshida : In this report.
3) T. Narita et al. : JAERI-M 5769 (1974)
4) S. Igarasi : JAERI 1224 (1972)
5) C. A. Engelbrecht and H. Fiedeldy : Ann. of Phys. 42, 262 (1967)

II-C-3 Evaluation of the Nuclear Data on ^{235}U

Hiroyuki Matsunobu*

Evaluation work of the nuclear data (α, ν_p, σ_{el}, σ_{in}) on ^{235}U in the energy range from 1 keV to 15 MeV has been performed as a part of evaluation works in the sub-working group of JNDC.

One of the purposes of evaluation for α(capture to fission ratio is to obtain capture cross section σ_c using the evaluated α and σ_f, because the experimental data for σ_c of ^{235}U are poor. However, there are also no experimental data for α in the energy range above 1 MeV. Accordingly, capture cross section in that energy range is obtained by theoretical calculation based on the optical model and statistical theory, and normalized to the experimental data below 1 MeV.

α-value of ^{235}U in the energy range from 1 keV to 1 MeV was evaluated on the basis of the compiled experimental data. The energy dependence of evaluated α-value was given by four polinomial functions. The energy intervals for the four functions are 1∿4.75 keV, 4.75∿16.0 keV, 16.0∿85.0 keV, and 85.0 keV∿1 MeV.

On the other hand, there are many experimental data for the prompt neutron number per fission ν_p of ^{235}U in the energy range below 15 MeV, and the energy dependence of ν_p has been studied by many researchers. In present evaluation, the energy dependence was represented by three straight lines using x^2-method in the energy range from 40 keV to 15 MeV. The energy intervals for these straight lines are 40 keV∿2 MeV, 2.0∿7.5 MeV, and 7.5∿15 MeV.

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* Sumitomo Atomic Energy Industries, Ltd.

The results of evaluation for α and ν_p were reported at the Atomic Energy Society of Japan held in October 1974.

The experimental data of elastic and inelastic scattering cross sections are very scanty compared with those of other neutron data for ^{235}U, and (the energy range in which the measurements were done is narrow.) the measured data are limited in the narrow energy ranges. In addition, there are some large discrepancies between the measured data. Accordingly, it is difficult to perform a consistent evaluation over the energy range 1 keV to 15 MeV on the basis of the compiled experimental data.

Therefore, in present evaluation, the optical model calculation was done using ELIESE-3 code in order to check the energy dependences of the experimental data and obtain the cross sections in the energy range in which the measurements have not been done yet. The optical potential parameters to input to the ELIESE-3 code were obtained by fitting the cross section calculated by the TOTAL code to the experimental data of the total cross section for ^{235}U.
The obtained parameters include the energy dependences of the first and the second orders.
The calculated cross section shows a good agreement with the experimental data for the elastic scattering cross section.

In calculation of the inelastic scattering cross section, the competition processes were taken into account for (n,f), (n,γ), (n,2n), and (n,3n) reactions. The results of evaluation for the elastic and inelastic scattering cross sections will be reported at the Atomic Energy Society of Japan which will be held in November 1975.

II-C-4 Evaluation of ^{241}Am Nuclear Data

Sin-iti Igarasi

Evaluations of nuclear data for ^{241}Am are performed on total, elastic scattering, inelastic scattering, fission, capture, (n,2n) and (n,3n) cross sections, as well as the average number of neutrons per fission They are mainly obtained with the theoretical calculations, because the existing experimental data for ^{241}Am are very scarce, except for the fission cross section.

Results of the present evaluation are published to JAERI-M 6221. Fig.1 shows the evaluated cross sections obtained in this work.

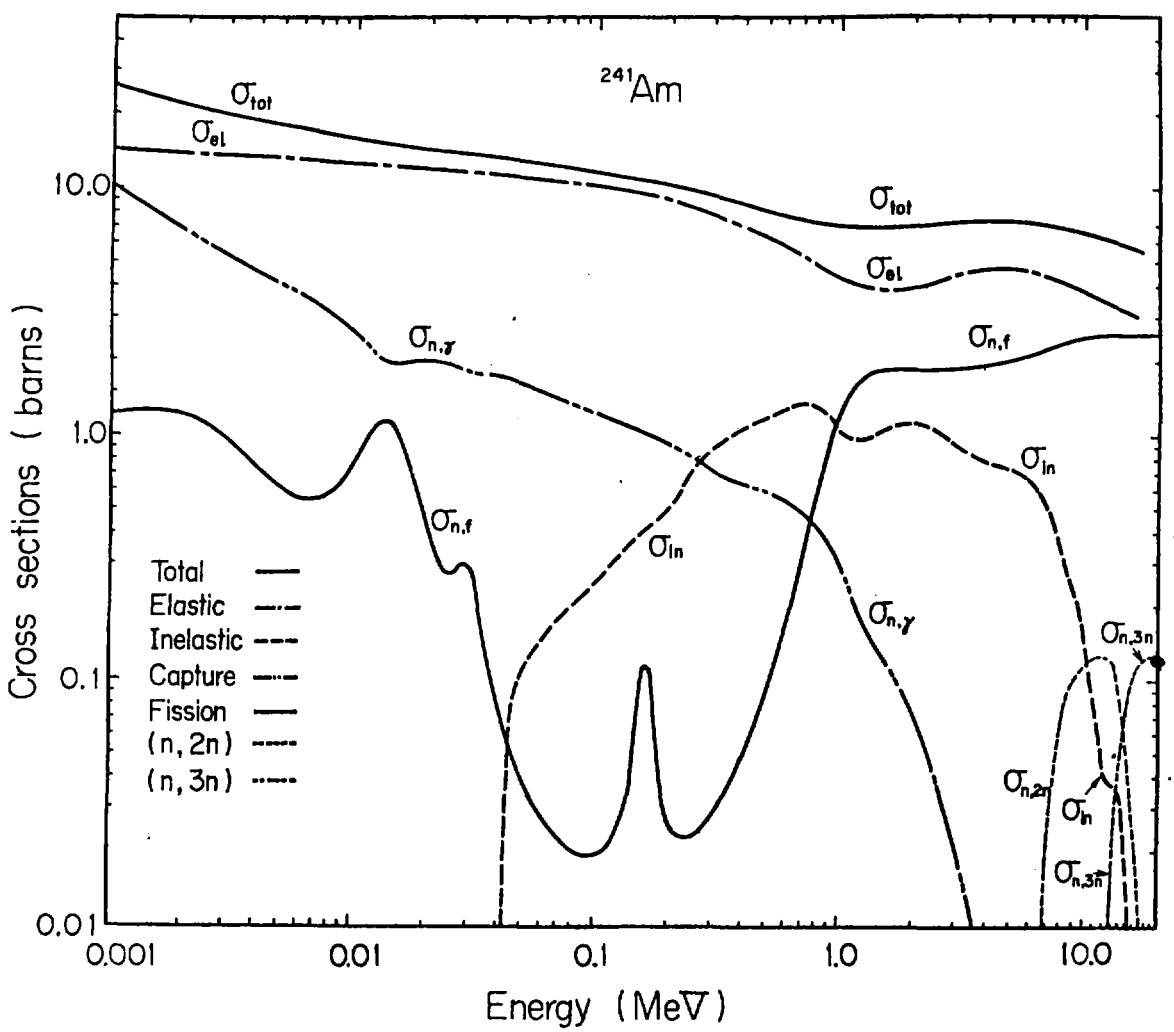

Fig.1 Evaluated cross section curves of ^{241}Am.

II-C-5 Cross Section Evaluation of 27 Fission Product Nuclides *)

S. Iijima[+], T. Nakagawa,[++] Y. Kikuchi,[++] M. Kawai,[+]
H. Matsunobu,[+++] K. Maki,[++++] and S. Igarasi[++]

Earlier evaluation[1)] of neutron cross sections of 28 fission product nuclides was revised. Main improvements are in the method of calculation of resonance cross section and statistical model calculation. Thermal and resonance cross sections were calculated from resonance parameters. A particular care was paid for mission levels. The difference between the measured and the calculated thermal cross sections was assumed as being of 1/v form and was added to the calculated cross section curve. A modified multi-level Breit-Wigner formula was developed for the calculation of elastic scattering cross section from resonance parameters in order to avoid the well-noted occurrence of negative cross section value. A spherical optical potential and the statistical theory were used to calculate the cross sections above resonance region. The effects of neutron width fluctuation and level interference were taken into account.[2)] The calculation was adjusted by capture data when available. The joining energy between the resonance cross section and the cross section calculated by statistical theory was determined for each nuclide. A Monte Carlo statistical analysis was made to this purpose.

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*) Work performed as a part of the activities of JNDC, JAERI

+) NAIG Nuclear Research Laboratory, Nippon Atomic Industry Group Co., Ltd.
++) Japan Atomic Energy Research Institute
+++) Sumitomo Atomic Energy Industries, Ltd.
++++) Atomic Energy Research Laboratory, Hitachi Ltd.

Table 1. Comparison of Evaluated Capture Cross Sections at 30 keV (mb)

	Cook[3]	Benzi[4]	Schmittroth[5]	Lautenbach[6]	Present
Zr-93	86	144	90	226	177
Mo-95	405	336	392	414	384
MO-97	333	378	371	475	359
Tc-99	716	844		981	761
Ru-101	2611	902	850	1094	1097
Ru-102	340	348	244	378	314
Rh-103	791	793		804	984
Ru-104	149	155	160	387	177
Pd-105	761	1221	984	1217	1178
Ru-106	80			356	104
Pd-107	708	1245	894	1198	1165
Ag-109	714	897		1470	1215
I -129	366		459	445	490
Xe-131	548	491	364	358	424
Cs-133	456	693		686	518
Cs-135	121	294	64	248	275
Cs-137	17	36	8	226	22
Nd-143	334	339		185	243
Ce-144	35		35		65
Nd-144	147	92		72	77
Nd-145	290	419		298	300
Pm-147	1054	999		897	938
Sm-147	1146	1236		670	1005
Sm-149	1580	1687		1248	1645
Sm-151	3335	2100		1836	1825
Eu-153	2605	2702		2465	2566
Eu-155	2320			1773	1885

The results are stored on magnetic tape in ENDF/B-3 formats. It contains the total, elastic scattering, inelastic scattering, and capture cross sections for energy range thermal to 15 MeV. Table 1 shows the capture cross sections at 30 keV in comaprison with other evaluated data.

References :

1) Japanese Nuclear Data Committee : JAERI-M 5752 (1974)

2) S. Igarasi : J. Nucl. Sci. and Tech. 12 67 (1975)

3) J.L. Cook : AAEC/TM 549 (1970)

4) V. Benzi et al. : CCDN-NW/10 (1969), Doc. CEC(71)9 (1971)

5) A.F. Schmittroth and R.E. Schenter : HEDL-TME 72-63, ENDF-194 (1973)

6) G. Lautenbach : RCN 191 (1973)

II-C-6 Compilation of ^{239}Pu Resonance Parameters

T. Yoshida*

The paper on this subject was published in a report, JAERI-M 5979, with an abstract as follows.

As a part of the evaluation work by a working group of the Japanese Nuclear Data Committee, ^{239}Pu neutron cross sections are being evaluated at present. This is an interim report of the work, and collected data of the Breit-Wigner single-level parameters for ^{239}Pu resonances are compiled in tables with a summary of the relevant experimental informations. The multilevel parameters are also given in the Appendix. Subsequent evaluation for the ^{239}Pu resonance parameters will be made on the basis of this compilation.

* Nippon Atomic Industry Group Co., Ltd.

II-C-7 Evaluated Excitation Function of the $^{19}F(n,2n)^{18}F$ Reaction

T. Sugi and K. Nishimura

Excitation function of (n,2n) cross section for ^{19}F has been calculated by using statistical model[1] of nuclear reactions. The method used generated the shape ($\sigma_{n,2n}$ / $\sigma_{n,M}$) curve of the $^{19}F(n,2n)^{18}F$ reaction, and the neutron energy region studied was from 11 to 20 MeV. The excitation function thus obtained was normalized at 14.7 MeV to an evaluated cross-section value of 54.1 ± 5.4 mb[2]. Good agreement was found for abundant experimental data in the whole energy region.

The present evaluated cross-section curve was close to ENDF/B-4 curve in the energy region from threshold to 14.4 MeV. Above 14.4 MeV it showed lower cross-section values more than 10 %, as compared with the ENDF/B-4 curve. UKNDL curve was systematically higher than the both present and ENDF/B-4 curves up to 15 MeV.

References

1) S. Pearlstein, Nucl. Sci. Eng. 23 (1965) 238

2) Z. T. Bödy, INDC(HUN)-10 (1973)

II-C-8 Tests of JNDC FP Group Constants (Preliminary Version)

Y. Kikuchi and A. Hasegawa

Tests of FP group constants produced from the preliminary version of JNDC evaluated data[1] have been continued, while the revision of evaluation has been performed. It was found[2] from the integral tests for FP mixtures that the preliminary version of JNDC group constants might give too large capture cross section. It is difficult, however, to discuss the reliability of the cross section set from the integral data of mixtures, since the mixtures are composed of so many isotopes.

On the other hand, the reactivity worths of 57 isotopic samples were measured at STEK cores in RCN-Petten, and the preliminary results were already published[3,4]. The correction of self-shielding effect is difficult in these experiments, and these experimental results are noted to be preliminary. It is worthwhile, however, to check our set with these integral data. The flux and the adjoint flux were informed as a private communication.

The calculated reactivities with the JNDC set are compared with the experimental data, and the followings can be said :

1) The calculated values with the JNDC set are a little larger than the experimental ones for

   Mo-95, Mo-97, Ru-101, Cs-133, Nd-143,

   Nd-145, Pm-147, Sm-147, Eu-153. (category 1)

2) The calculated values are a little smaller for

   Tc-99, Rh-103, Pd-105, Pd-107, Ag-109,

   Sm-149. (category 2)

3) The calculated values are much larger than the experimental ones for

Ru-102, Ru-104, I-129 Nd-144. (category 3)

4) The calculated values are much smaller for

Sm-151. (category 4)

5) The core dependence of the calculated values does not agree at all with the experimental ones for

Zr-93, Cs-135. (category 5)

The agreement is satisfactory for the nuclides of category 1 and 2. The tendency of these slight disagreements was taken into account in the revision work for these nuclides so as to improve the agreement. The disagreement for the nuclides of category 3 may be partly explained with our rough treatment of inelastic scattering. As for Sm-151, the JNDC evaluated curve is very different from the other evaluated data and might be in error. The disagreement of the core dependence for the nuclides of category 5 is not understandable.

It is concluded that the disagreement for categories 3, 4 and 5 seems too large to be explained as due to the error of the nuclear data. Therefore these results were used in the revision work only as references. The detailed discussion concerning various tests of JNDC FP group constants (preliminary version) is given in Ref. 2.

References :

1) JNDC, Evaluation of Fission Product Nuclear Data for Fast Reactor, JAERI-M5752 (1974)

2) Y. Kikuchi, A. Hasegawa, K. Tasaka, H. Nishimura, I. Otake, and S. Katsuragi, JNDC Fission Product Group Constants - Preliminary Version-, JAERI-M 6001 (1975)

3) E. K. Hoekstra, Fast Reactor Programme, Second Quarter 1973, Progress Report RCN-190 (1973)

4) E. K. Hoekstra, Fast Reactor Programme, Third Quarter 1973, Progress Report RCN-199 (1973)

III. KYOTO UNIVERSITY

A. Institute of Atomic Energy

III-A-1 (n,2n) cross sections for ^{237}Np

T. Nishi, I. Fujiwara, N. Imanishi

The cross section for the $^{237}Np(n,2n)$ reaction was measured at 9.6 and 14.2 MeV by observing alpha-activity of ^{236}Pu built up in the irradiated neptunium samples.

Neutrons with an energy of 9.6 MeV were generated by the reaction $^{9}Be(^{3}He,n)^{11}C$ with the 30 μA beam of 2.8 MeV ^{3}He impinging on a thick target of beryllium in the Kyoto University Van de Graaff machine, and 14.2 MeV neutrons were produced by the reaction $^{3}H(d,n)^{4}He$ with an ordinary Cockcroft-Walton machine.

The spectra of neutrons generated by the reaction $^{9}Be(^{3}He,n)^{11}C$ are rather complex. There are two groups of neutrons avobe the threshold energy of the reaction $^{237}Np(n,2n)$ [Q = -6.619 MeV]; the energies of the respective groups are about 9.6 and 7.6 MeV. We measured the flux of each group using threshold detectors. The flux monitor-reactions used were the $^{197}Au(n,2n)^{196}Au$, $^{203}Tl(n,2n)^{202}Tl$, and $^{238}U(n,2n)^{237}U$ reactions. The same reactions were used for the measurement of the flux of 14.2 MeV neutrons.

Neptunium sample was purified chemically from contaminating plutonium, and converted to oxide. The oxide targets of 30 to 80 mg/cm^2 thickness were mounted on aluminum foils, stacked with the above flux monitors, and irradiated for 48 to 70 hours.

The irradiated neptunium samples were allowed to decay for several weeks to ensure that the 22.5 h ^{236}Np isomer decayed completely to its daughters. Then a known amount of ^{238}Pu or ^{239}Pu was added as a tracer to each irradiated neptunium sample. The alpha-activity ratio of ^{236}Pu/^{237}Np was measured with the following two-step measurement: first, the alpha-activity ratio of (^{238}Pu or ^{239}Pu)/^{237}Np was observed using a small portion of the sample; second, the alpha-activity ratio of ^{236}Pu/(^{238}Pu or ^{239}Pu) was determined after the chemical separation of plutonium from neptunium. The two-step measurement was useful since the alpha-activity ratio ^{236}Pu/^{237}Np of the irradiated sample was too small to be observed directly.

From the neutron fluxes and the alpha-activity ratios of ^{236}Pu/^{237}Np, values of the formation cross section of ^{236}Pu were found to be 0.16 ± 0.02 and 0.17 ± 0.02 b at 9.6 and 14.2 MeV, respectively. When the correction of an (EC/β^-) branching fraction[1)] of 1.08 is applied, the respective formation cross sections of the 22.5 h ^{236}Np isomer are deduced to be 0.34 ± 0.05 and 0.36 ± 0.05 b. It was previously found[2)] that the long-lived isomer in ^{236}Np was produced in neptunium samples irradiated with neutrons generated in the actuation of thermonuclear devices, and the ratio ^{236}Np(long)/^{236}Pu was 0.68 ± 0.08. The ratio yields the total ^{237}Np(n,2n) cross section values of 0.45 and 0.51 b at 9.6 and 14.2 MeV, respectively.

Previously the cross section to the 22.5 h ^{236}Np isomer was measured by Parkin and Coleman[3] to be 0.39 ± 0.06 b at 14.2 MeV, and by Landrum et al.[4] at several energies around 14 MeV. The data by Landrum et al., interpolated at 14.2 MeV, is 0.33 ± 0.06 b. Our result is in good agreement with those values.

References:

1) M. R. Schmorak, Nucl. Data Sheets B6 (1970) 623

2) W. A. Myers, M. Lindner, and R. S. Newbury, J. Inorg. Nucl. Chem. 37 (1975) 637

3) J. L. Parkin and R. F. Coleman, J. Nucl. Energy, 14 (1961) 69

4) J. H. Landrum, R. J. Nagle, and M. Lindner, Phys. Rev. C8 (1973) 1938

B. Research Reactor Institute

III-B-1 The Effect of Temperature on the Total Cross Section of Beryllium for Thermal Neutrons

K. Kanda, H. Kadotani*, and O. Aizawa**

A paper on this subject was submitted to the Journal of Nuclear Science and Technology. The total cross section for beryllium in the 0.002~0.3 eV neutron energy range was measured by means of a transmission technique at four different temperatures of the sample, namely, 300°, 573°, 773° and 973°K, while the former data showed only at 300° and 440°K. (Fig. 1)

The scattering kernel was directly calculated from the frequency distribution function, not by using $S(\alpha, \beta)$ such as GASKET-FLANGE method. The total cross sections obtained by integrating the scattering kernel from Sinclair model, Young-Koppel model and Raubenheimer-Gilat model show little difference among them. The experimental values are in good agreement with the calculated ones for all measured temperatures of the sample.

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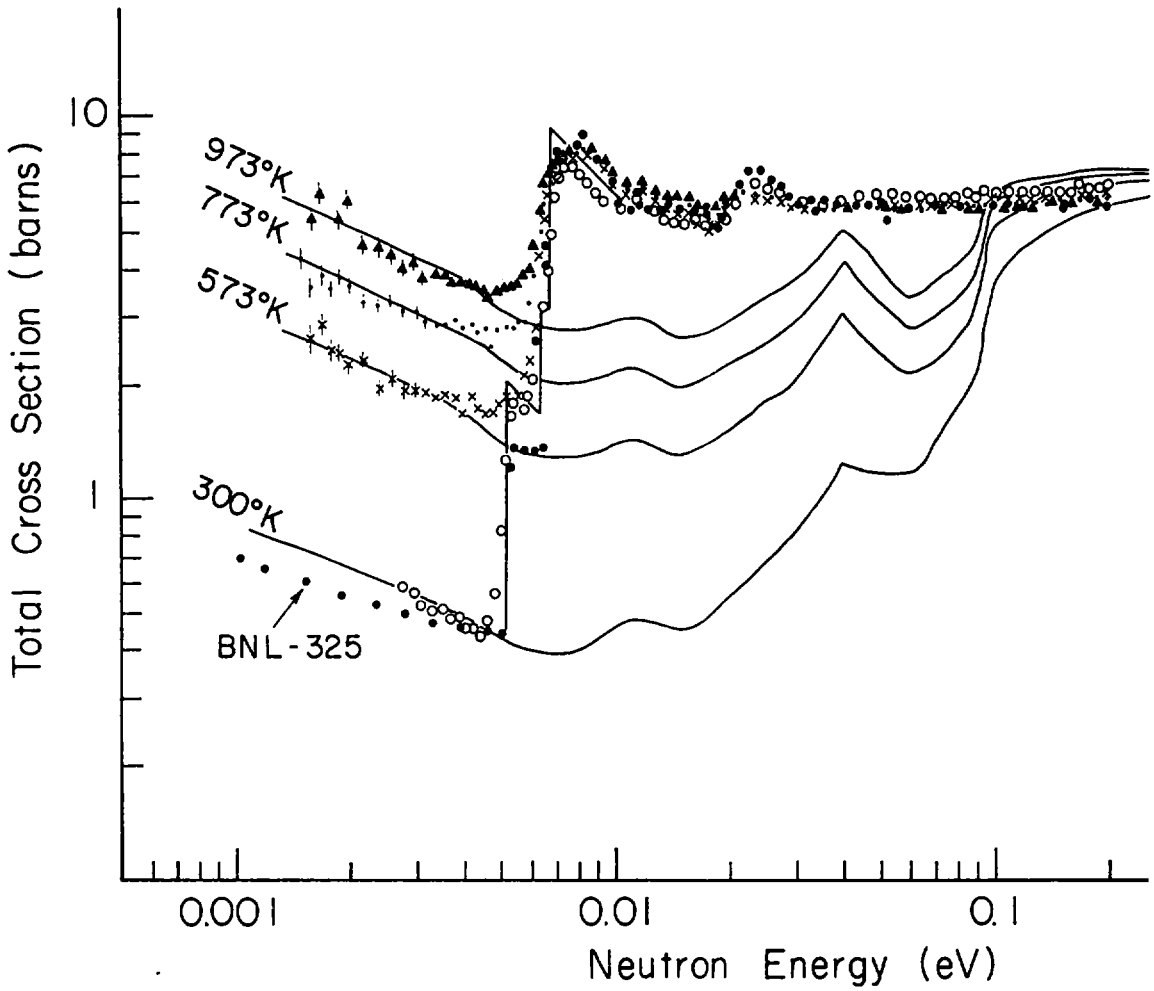

Fig. 1 Comparison between experiment and calculation at four different temperature

III-B-2

Measurement of the neutron-proton total cross section by the use of 24 keV iron filtered neutrons

Y. Fujita, K. Kobayashi, T. Oosaki* and R. C. Block**

The neutron-proton total cross section was measured by making the time-of-flight transmission measurement with 24 keV iron filtered neutrons at a 20 m flight path of KURRI electron linac facility. For the transmission sample, water was employed and it was replaced with a SiO_2 plate in the sample "*out*" run. The experimental system was essentially the same as for the case of Be, C and O experiment[1].

The measured value of the cross section was 17.740 ± 0.023 b at the effective energy of 23.645 ± 0.068 keV. In Fig.1, the result is compared with calculated values using the effective range formula and two sets of recently tabulated parameters. The parameters are listed in Table 1. The present result is very close to the 23.645 keV cross section calculated by Lomon and Wilson's parameters[2] and it is approximately 1.5 standard deviations lower than the calculated value based on Dilg's parameters[3].

References:

1) R. C. Block, Y. Fujita, K. Kobayashi and T. Oosaki, J. Nucl. Sci. Technol., 12 (1975) 1.

2) E. Lomon and R. Wilson, Phys. Rev., C 9 (1974) 1392.

3) W. Dilg, Phys. Rev., C 11 (1975) 103.

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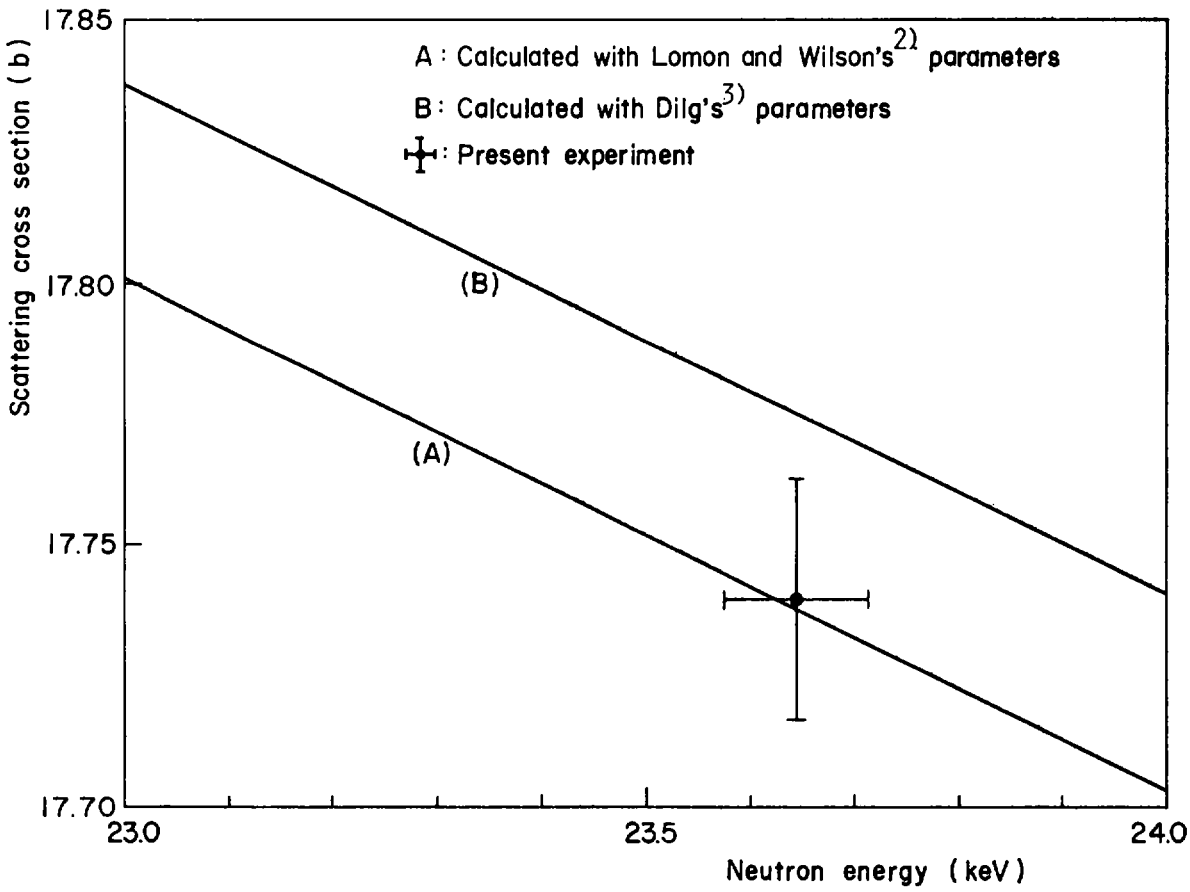

FIG. 1 MEASURED AND CALCULATED N-P SCATTERING CROSS SECTIONS NEAR 24 KEV

Parameters	Lomon and Wilson's values (fm)	Dilg's values (fm)
a_t : triplet scattering amplitude	5.414 (5)	5.423 (4)
a_s : singlet scattering amplitude	- 23.719 (13)	- 23.749 (9)
r_t : triplet effective range	1.750 (5)	1.760 (5)
r_s : singlet effective range	2.76 (5)	2.81 (5)

$$\sigma = \frac{3\pi}{k^2 + (\frac{1}{2}k^2 r_t - \frac{1}{a_t})^2} + \frac{\pi}{k^2 + (\frac{1}{2}k^2 r_s - \frac{1}{a_s})^2}$$

Table 1 Parameters used in the calculations and the effective range formula

III-B-3

Measurement of neutron total cross section of thorium by the use of 24 keV iron filtered neutrons

K. Kobayashi, Y. Fujita and T. Oosaki*

The neutron total cross section of thorium was measured by making the time-of-flight transmission measurement with 24 keV iron filtered neutrons at a 20 m flight path of KURRI electron linac facility, in order to experimentally evaluate the resonance parameter sets given by Forman et al.[1] and ENDF/B-IV. The experimental system was essentially the same as for the case of Be, C and O experiment[2].

The measurement were carried out for six kinds of thorium thickness and the results of the measured apparent cross section values are shown in Fig.1 along with calculations. In the calculations of the cross section, BABEL[3] and MCROSS[4] codes were used. Resonance parameters used in the calculations are listed in Table 1.

The comparison of experiment and calculation shows that the agreement is better in the Cal.1 using Forman et al.'s parameters than the Cal.3 using ENDF/B-IV parameters.

References:

1) L. Forman et al., Phys. Rev. Letters, 27 (1971) 117.
2) R. C. Block et al., J. Nucl. Sci. Technol., 12 (1975) 1.
3) Y. Ishiguro and S. Katsuragi, JAERI-memo 3785 (1969).
4) H. Takano, JAERI-memo 4721 (1972).

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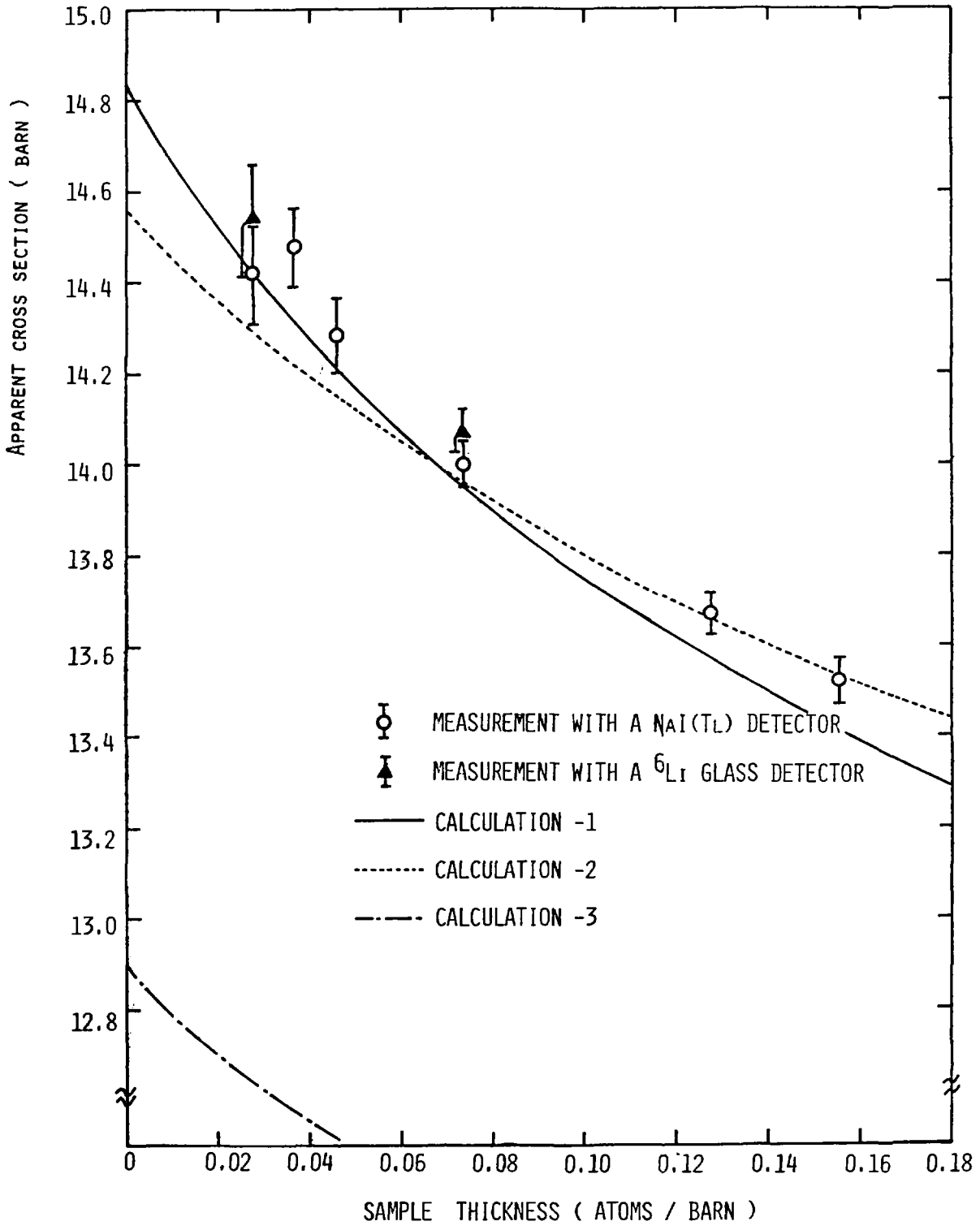

FIG. 1 RESULTS OF EXPERIMENTS AND CALCULATIONS

	CAL.1	CAL.2	CAL.3
COMPUTOR CODE FOR CROSS SECTION CALCULATION	BABEL & MCROSS	BABEL & MCROSS	BABEL & MCROSS
S WAVE S	0.793×10^{-4}	0.730×10^{-4}	0.730×10^{-4}
Γ_N^0	1.8 MEV *	0.924 MEV **	0.924 MEV **
P WAVE S (J = 1/2)	1.718×10^{-4}	1.2×10^{-4}	1.2×10^{-4}
Γ_N^0 (J = 1/2)	3.9 MEV	1.518 MEV	1.518 MEV
S (J = 3/2)	1.711×10^{-4}	1.2×10^{-4}	1.2×10^{-4}
Γ_N^0 (J = 3/2)	1.95 MEV *	0.795 MEV **	0.759 MEV **
R (CM)	9.65×10^{-13} *	9.65×10^{-13} *	8.9874×10^{-13} **

TABLE 1 RESONANCE PARAMETERS USED IN THE CALCULATION

* FORMAN ET AL. , ** ENDF/B-IV

III-B-4

Fission Averaged Cross Sections of Some Threshold Reactions Measured with Fast Reactor, YAYOI

Katsuhei Kobayashi, Itsuro Kimura,
Masaharu Nakazawa* and Masatsugu Akiyama*

A paper on this subject was submitted to the Journal of Nuclear Science and Technology and a part of this work will be presented at the ASTM-EURATOM Symposium on Reactor Dosimetry at Petten, Netherlands in this September.

Fission averaged cross sections of twenty one threshold reactions were measured in the core center of YAYOI** which was a fast neutron source reactor. Fast neutron spectrum in the core was experimentally analyzed by using a set of activation foils and micro-fission counters, prior to the cross section measurement. It was found that the shape of the fast neutron spectrum was approximately the same as that of fission neutrons above about 2 MeV. This fact was also confirmed by theoretical calculation.

Since this neutron field has scarce thermal and epithermal neutrons, measurement of nuclei produced by threshold reactions is not interfered by (n,γ) reactions which are induced by thermal and epithermal neutrons. Moreover, considerably high fast neutron flux (about 5×10^{11} n/cm^2/sec) enables to measure cross sections with small values.

The present results are given in Table 1, and they in general agree with the previous values obtained in a thermal reactor core or with a fission plate within an experimental error, while they are systematically smaller by about 10 % than those recommended by Fabry. The measured values are also compared with the results calculated by Pearlstein based on a statistical model.

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Table 1 Present values of fission averaged cross sections measured in YAYOI

Reaction	Present result (mb)
$^{24}Mg(n,p)^{24}Na$	1.36 ± 0.065
$^{27}Al(n,p)^{27}Mg$	3.64 ± 0.17
$^{46}Ti(n,p)^{46}Sc$	10.9 ± 0.59
$^{47}Ti(n,p)^{47}Sc$	18.9 ± 0.87
$^{48}Ti(n,p)^{48}Sc$	0.256 ± 0.013
$^{51}V(n,p)^{51}Ti$	0.456 ± 0.023
$^{51}V(n,\alpha)^{48}Sc$	0.0197±0.0012
$^{58}Ni(n,2n)^{57}Ni$	0.00534±0.00025
$^{59}Co(n,\alpha)^{56}Mn$	0.131 ± 0.0061
$^{63}Cu(n,\alpha)^{60}Co$	0.484 ± 0.034
$^{63}Cu(n,2n)^{62}Cu$	0.116 ± 0.016
$^{64}Zn(n,p)^{64}Cu$	30.9 ± 2.1
$^{66}Zn(n,p)^{66}Cu$	0.534 ± 0.038
$^{90}Zr(n,2n)^{89}Zr$	0.229 ± 0.015
$^{92}Mo(n,p)^{92m}Nb$	6.11 ± 0.29
$^{92}Mo(n,\alpha)^{89}Zr$	0.0381±0.0024
$^{93}Nb(n,\alpha)^{90m}Y$	0.0210±0.0011
$^{93}Nb(n,2n)^{92m}Nb$	0.430 ± 0.028
$^{232}Th(n,f)^{140}Ba$	78.6 ± 3.9
$^{238}U(n,2n)^{237}U$	15.7 ± 0.80
$^{238}U(n,f)^{140}Ba$	294 ± 15

III-B-5

Measurements and Analyses of Energy and Space Distributions of Fast Neutrons in Test Assemblies

Hiroshi Nishihara*, Itsuro Kimura, Katsuhei Kobayashi, Shu A. Hayashi, Shuji Yamamoto, Satoshi Kanazawa*, Masato Ando*, Tetsuo Matsumura* and Masayuki Nakagawa**

A part of this work was presented at the Conference of Nuclear Cross Sections and Technology at Washington, D.C. in March 1975 and will be published in its proceeding soon.

In order to assess nuclear data or group constants of some important reactor materials, fast neutron spectra in these materials have been measured by the time-of-flight method using an electron linear accelerator as a pulsed neutron source and the results have been compared with the predicted ones which were obtained by theoretical calculations with several different group constants. Outline of this work was described in NEANDC(J)36L, last year's issue of this progress report.

At the Washington Conference, we presented fast neutron spectra in iron and stainless steel (JIS SUS-304) to evaluate group constants, JAERI-FAST, modified JAERI-FAST(JAERI-E), DLC-2D(ENDF/B-III) and ABBN(Abagyan et al.). As shown in Fig.1 and Fig.2, measured spectra for both assemblies agree the calculated with DLC-2D. However, rather poor agreement is seen on the JAERI-FAST spectrum in iron. It is considerably improved when we use the JAERI-E or ABBN. On the contrary, all of the calculated spectra in stainless steel agree each other and the measured one much better than the case of iron. In addition to the energy spectrum measurement, spatial distributions of neutrons were measured in both assemblies and were compared with the predicted. Details will be described in the proceeding of the Conference.

Similar works on aluminium and on iron with lead reflector are being studied. Futhermore, we started to study sensitivity of neutron cross section to neutron spectrum.

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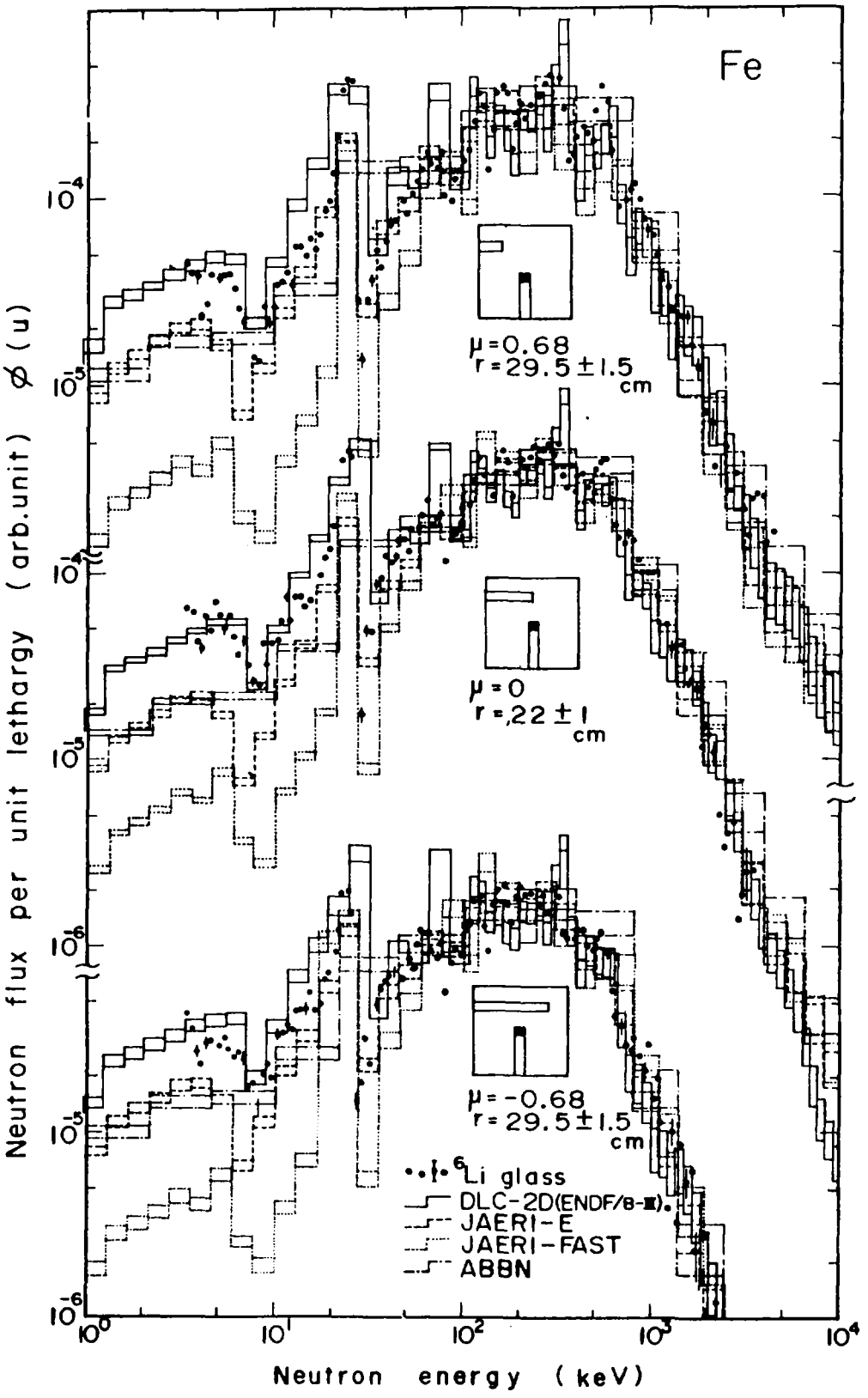

Figure 1 Neutron spectra in iron

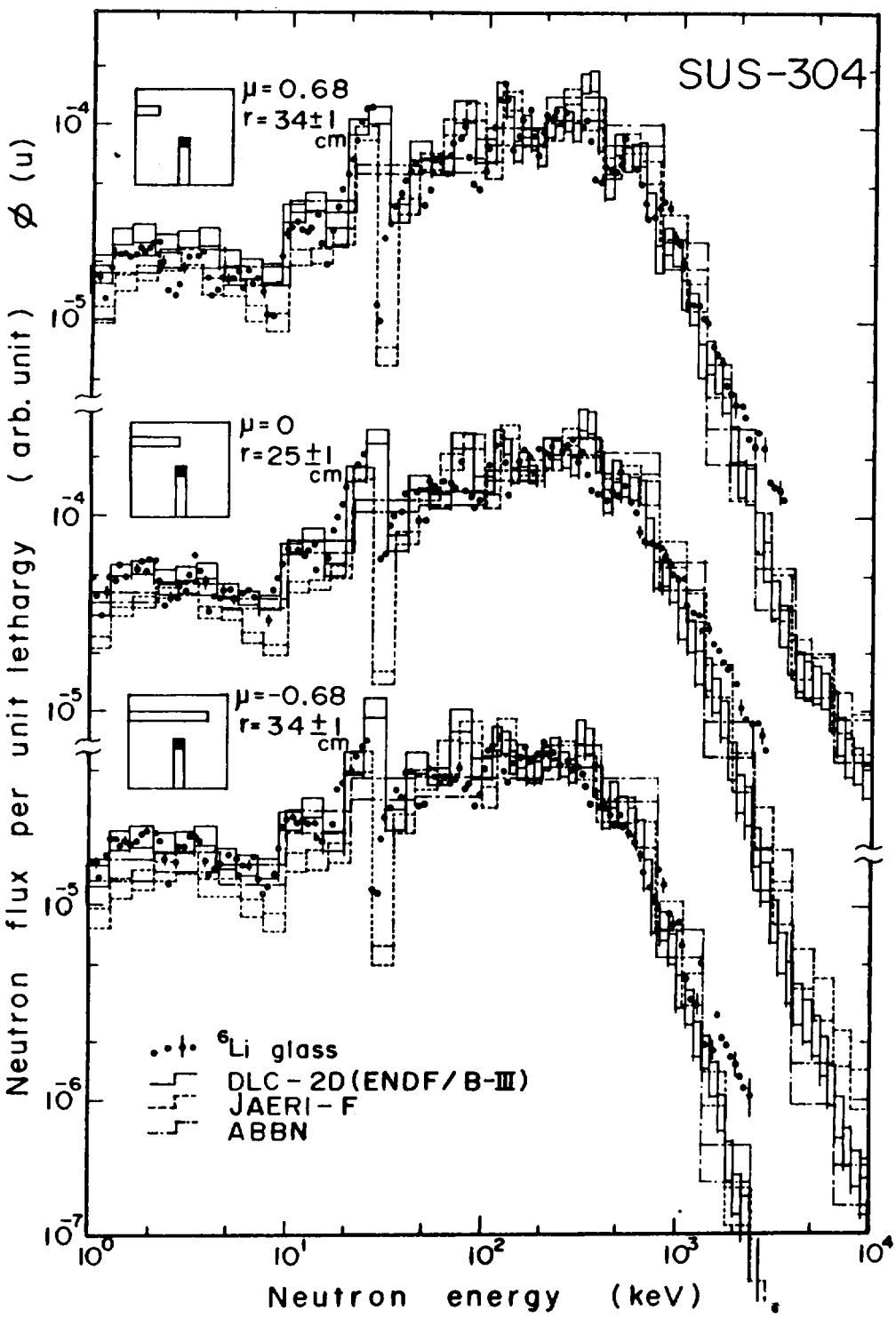

Figure 2 Neutron spectra in stainless steel

III-B-6 Half-lives and Gamma-ray Energies of $^{102-105}Mo$

Y.Kiso*, R.Matsushita, J.Takada, T.Tamai and H.Takemi*

A paper on this subject was submitted to J. Nucl. Sci. Technol.. A paper electrophoretic technique for rapid separation of molybdenum from fission products has been developed. This technique permits direct observation of the decay of 11.8 min ^{102}Mo, 70 sec ^{103}Mo, 66 sec ^{104}Mo and 40 sec ^{105}Mo without interference except for their daughter technetium. The γ-ray spectra were measured with a high resolution Ge(Li) detector. Half-lives of $^{102-105}Mo$ were determined by demonstrating a genetic relationship of the known γ-ray peak of technetium daughters, respectively[1-5]. From the decay plots of the observed photopeaks, many unknown short-lived γ-peaks with 10-70 sec were observed. The mass assignment of new γ-ray peaks was made by following their decay rates. In Table 1-3, our results were summarized with the published data.

Table 1 Half-lives of $^{102-105}Mo$ determined by a genetic relationship of their Tc daughters

Mass No.	Present work			Published data
	Mo	Tc		Mo
	$T_{1/2}$	E_γ(keV)	$T_{1/2}$	$T_{1/2}$
102	11.8 ± 0.4min	475.2	4.3 min	11.5 min (1)
103	70 ± 1 sec 70 ± 2 70 ± 1	136.5 403.7 563.3	50 sec	70 ± 10, 62, 60 ± 2 sec (2)
104	66 ± 2 sec	358.1	18.0 min	96 ± 6 (3), 64 ± 5 sec (4)
105	36 ± 3 sec 41 ± 5	105.6 143.0	7.6 min	40, 42 ± 3, 58 ± 14, 41 ± 2, 48 ± 4 sec (5)

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Table 2 Gamma-ray energies, relative intensities and half-lives of $^{102-104}Mo$

^{102}Mo			^{103}Mo or ^{104}Mo		
E_γ (keV)	I_γ (%)	$T_{1/2}$(min)	E_γ (keV)	I_γ (%)	$T_{1/2}$(sec)
149.3	89	12.2 ± 0.4	46.9	9.4	66 ± 3
211.3	100	12.4 ± 0.4	56.7	49.3	63 ± 1
224.3	32	13.7 ± 1.5	92.5	29.3	64 ± 2
			115.3	2.9	62 ± 5
			423.2	100.0	68 ± 5
			519.4	18.4	66 ± 2
			687.1	15.7	67 ± 5
			841.9	5.0	70 ± 6

Table 3 Gamma-ray energies, relative intensities and half-life of ^{105}Mo

Present work				Published data (5)	
E_γ (keV)	I_γ (%)	$T_{1/2}$(sec)		E_γ (keV)	I_γ (%)
69.7	440		58 ± 0.5	68.7	100
77.8	37.3	30 ± 0.6			
86.0	60.9		51.8 ± 0.5	93.1	13.5
123.5	92.2	34 ± 2			
147.9	100.0	34 ± 1		143.1	33
161.0	30.5	33 ± 1		159.2	13
174.0	62.8		50 ± 2	169.6	1.7
198.4	9.4	30 ± 1			
204.9	5.6	33 ± 3			
218.0	12.9		53 ± 3		
237.5	7.3	33 ± 3			
250.6	36.6	31 ± 1			
286.4	8.3	32 ± 2			
376.0	26.7		56 ± 2	376.0	12.4
389.0	2.8	30 ± 5			
468.9	16.1	36 ± 4			
609.0	11.9	42 ± 2			
620.4	10.4	40 ± 2			
750.7	13.8		54 ± 5		
1029.3	7.3		52 ± 3		
1040.7	27.9		49 ± 6		

References:

1) W.Seelmann-Eggebert, G.Pfennig and H.Munzel: "Chart of the Nuclides", 4th ed. Kernforschung m.b.H. Karlsruhe (1974)

2) D.C.Kocher: Nuclear Data Sheets, 13, 337 (1974)

3) G.P.Tercho, J.A.Marinsky: J. Inorg. Nucl. Chem., 26,1129(1964)

4) N.Trautmann, N.Kaffrell, H.W.Behlich, H.Folger, G.Herrmann, D.Hubscher: Radiochimica Acta, 18, 86 (1972)

5) F.E.Bertrand: Nuclear Data Scheets, 11, 449 (1974)

IV. KYUSHU UNIVERSITY

Department of Nuclear Engineering, Faculty of Engineering

IV-1 Scattering of 14.1 MeV Neutrons by ^{6}Li, ^{7}Li, ^{9}Be, ^{10}B and ^{11}B

M. Hyakutake, M. Sonoda, A. Katase, Y. Wakuta, M. Matoba
H. Tawara and I. Fujita*

A full paper on this work, which was outlined in the previous report (EANDC (J) 10L, P.22, 13L, P.29 and P.31), was published in J. Nucl. Sci. Technol., 11 (1974) 407-421 with an abstract as follows :

Using a time-of-flight spectrometer, the differential cross sections were measured for the elastic and inelastic scattering of 14.1 MeV neutrons by ^{6}Li, ^{7}Li, ^{9}Be, ^{10}B and ^{11}B. In the case of elastic scattering by ^{7}Li and ^{10}B, correction was applied to subtract the contribution of in-elastic scattering from the unresolved first excited state, after which, the elastic scattering data were compared with predictions based on the optical model. The potential parameters derived with a seven-parameter search yielded angular distributions agreeing with the present experimental data. The expressions for these parameters are presented as a function of mass number.

The experimental data on inelastic scattering were analyzed with the distorted wave Born approximation. The deformation parameters were estimated to be nearly equal to or larger than unity for these nuclei.

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IV-2 Scattering of 14.1 MeV Neutrons from Fe

M. Hyakutake, M. Matoba, T. Tonai*, J. Niidome**
and S. Nakamura***

A full paper on this work, which was outlined in the previous report (EANCD (J) 30L, P.49), was published in J. Phys. Soc. Japan 38 (1975) 606 with an abstract as follows :

Differential cross sections for the elastic scattering of 14.1 MeV neutrons from Fe and for the inelastic scattering to the first excited state at 0.85 MeV have been measured. The inelastically scattered neutrons were completely separated from elastically scattered ones by a time-of-flight spectrometer which had an energy resolution of 260 KeV for 14.1 MeV neutrons.

The engular distributions for elastic and inelastic scattering have been analyz ed by the optical model and the distorted wave Born approximation (DWBA), respectively. Both elastic and inelasitc scattering have also been analyzed using the coupled channel calculations. Reasonable fits to the data were obtained. The deformation parameters extracted are compared with those found from other experiments.

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IV-3 Angular Distributions of Neutrons from Pre-Compound Decay

Y. Irie, M. Hyakutake, M. Matoba, N. Koori and
M. Sonoda

Energy spectra for the ^{93}Nb(n,n') reaction at En = 14.1 MeV were integrated over whole solid angle and analysed with an expression of the form

$$\sigma(\varepsilon) = A\varepsilon\,\sigma_{inv}(\varepsilon)\,e^{U/T} + \pi\lambda\!\!\!^{-2}\sum_{\ell}(2\ell+1)T_{\ell}\,P_N(\varepsilon),\cdots \quad (1)$$

where

$$P_N(\varepsilon) = \sum_{\substack{n=n_0\\ \Delta n=+2}}^{\bar{n}} {}_nP_N\,\frac{\rho_n(U,\varepsilon)}{\rho_n(E)}\cdot g\cdot\frac{\lambda_c(\varepsilon)}{\lambda_c(\varepsilon)+\lambda_+(\varepsilon)}\cdot D_{n\ell}$$

and N stands for neutron.

The second term in eq.(1) shows the contribution from pre-compound decay based on geometry dependent hybrid model[1] (Fig. 1).

The pre-compound angular distributions are obtained by subtracting the compound isotropic ones from the experimental total angular distributions (Fig. 2). On the other hand, theoretical angular distributions from pre-compound decay were calculated from[2]

$$\sigma(U,Q) \propto \sum_{\ell_{n'}}(2\ell_{n'}+1)^2\,T_{\ell_{n'}}\sum_J \rho_{1,1}(U,J)\times\sum_{\ell}(\ell_n,\ell_{n'},0,0|\ell,0)^2 \times j_{\ell}(QR). \quad (2)$$

References :

1) M.Blann : Nuclear Phys. A213 (1973) 570.

2) Y. Irie et al : To be published in J. Phys. Soc. Japan 39 No. 2 (1975).

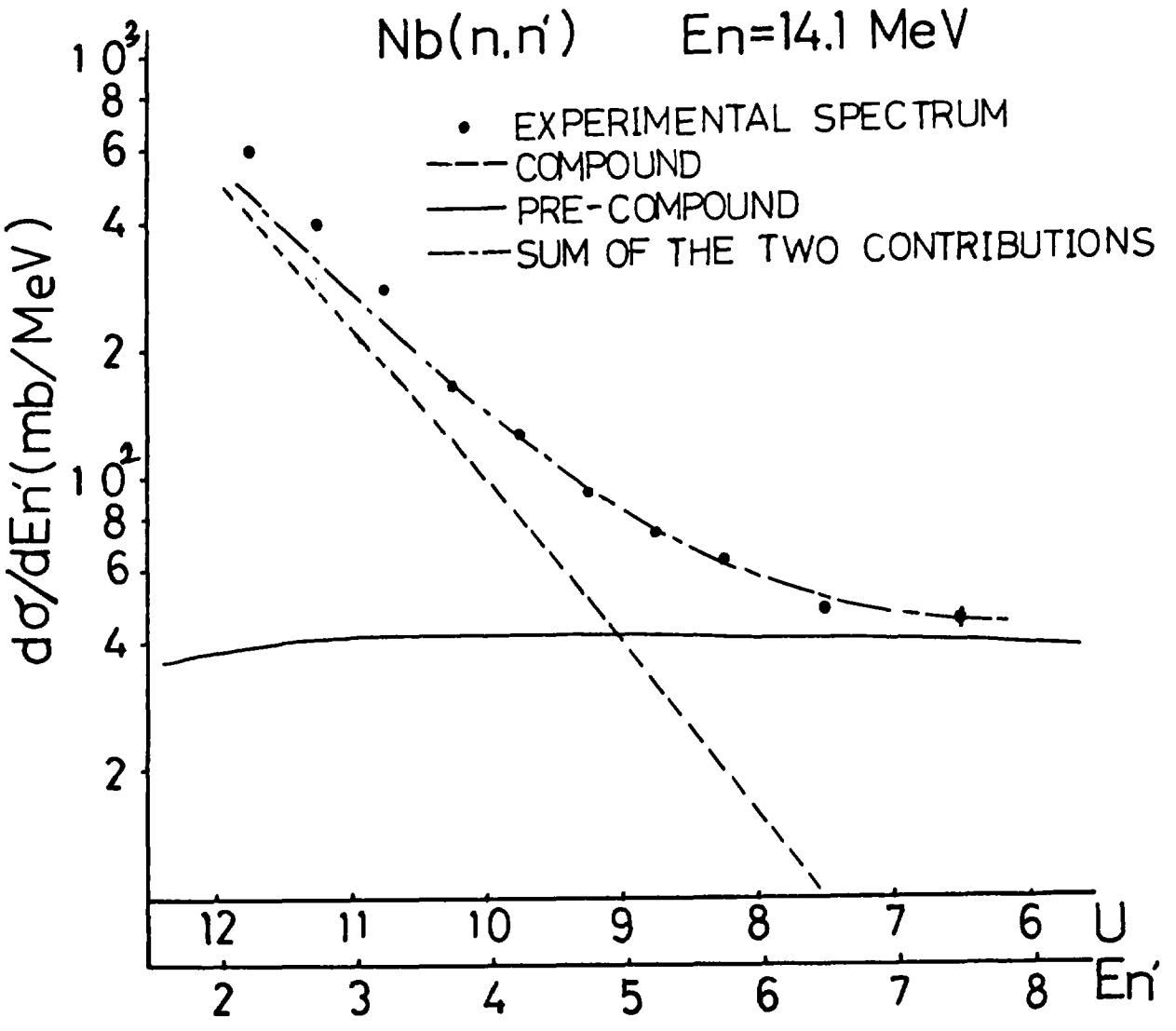

Fig. 1. The experimental total angular distributions were fitted with eq. (1). Parameters involved (A, T, ${}_nP_N$, g) were determined to minimize the chi - square :

$$\chi^2 = \sum_i \left\{ \frac{\sigma_{exp}(\varepsilon^i) - \sigma(\varepsilon^i)}{\Delta\sigma_{exp}(\varepsilon^i)} \right\}^2$$

where $\sigma_{exp}(\varepsilon^i)$, $\sigma(\varepsilon^i)$ and $\Delta\sigma_{exp}(\varepsilon^i)$ represent the experimental result, the calculated one and the error of $\sigma_{exp}(\varepsilon^i)$ at the ith energy, respectively. Experimental results are corrected for multiple scattering.

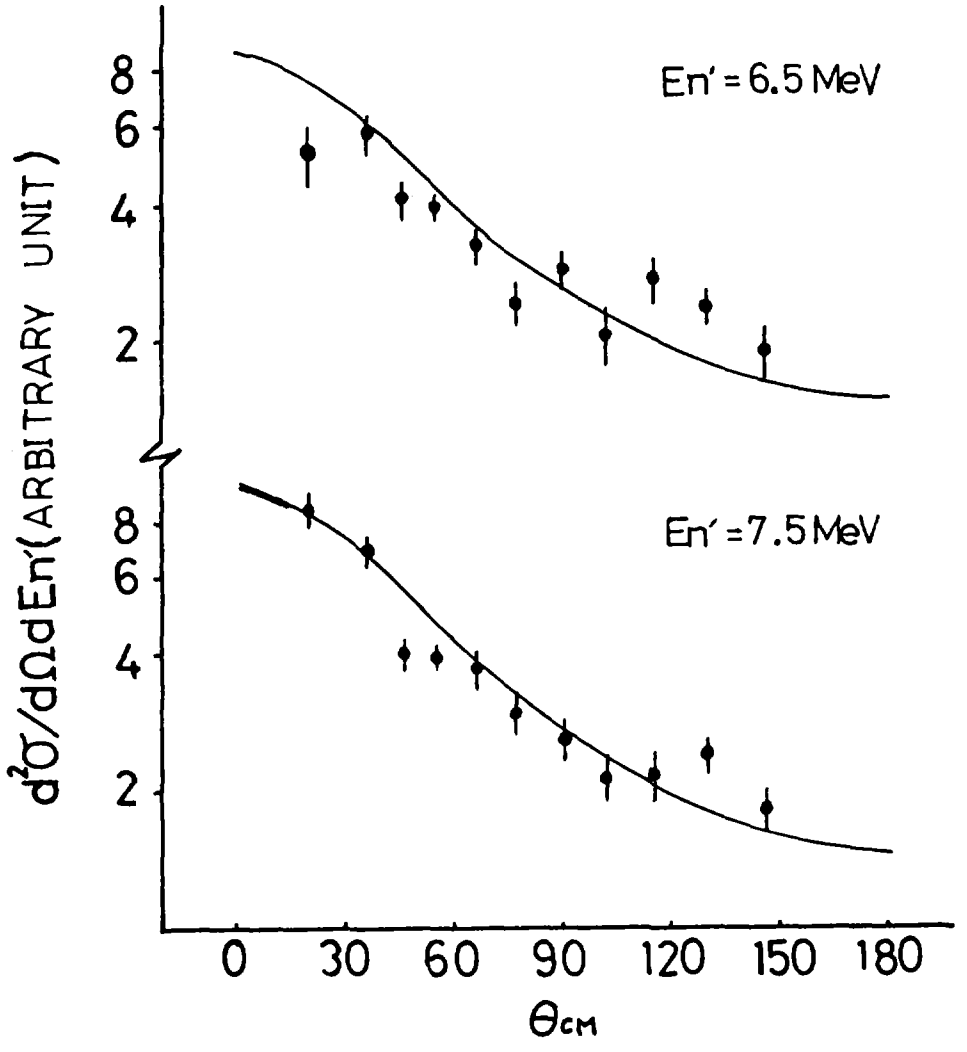

Fig. 2. Pre-compound angular distributions for ^{93}Nb(n,n') at E_n = 14.1 MeV.

• : Experimental angular distributions.

— : Theoretical angular distlibutions calculated from eq. (2), where ℓ_n = 4, R = 6.5 fm and the ratio of the moment of inertia of the nucleus to the rigid body value is 0.25.

IV-4 Pre-Compound Decay from Fe(n,n') Reaction of 14.1 MeV Neutrons

Y. Irie, M. Hyakutake, N. Koori, M. Tsuji*,
M. Matoba and M. Sonoda

A paper on this subject reported in NEANDC (J) 36L, p.53 has been published in J. Phys. Soc. Japan 37 (1974) 1461.

IV-5 Pre-equilibrium Proton Emission in the (n,p) Reaction on Indium at 14 MeV

J. Niidome#, M. Hyakutake, N. Koori, I. Kumabe and
M. Matoba

A full paper on this work, which was outlined in the previous report (NEAN CD(J) 36L, P.56) was published in Nuclear Physics A245 (1975) 509 with an abstract as follows :

The (n,p) reaction on indium has been studied at a bombarding energy of 14.1 MeV using a semiconductor - detector telescope. The emitted proton spectrum was measured and compared with the predictions of the pre-equilibrium model and the statistical evaporation model. The prediction of the pre-equilibrium model developed by Braga-Marcazzan et al. reproduced well the emitted proton spectrum and the cross sections.

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IV-6 Activation Cross Sections for (n,p) and (n,α) Reactions on Nd, Sm, Yb and Lu at 14.6 MeV

Tomomi SATO*, Yukinori KANDA and Isao KUMABE

A paper on this subject was submitted to the Journal of Nuclear Science and Technology and was accepted.

Activation cross sections for the (n,p) and (n,α) reactions on Nd, Sm, Yb and Lu have been measured at 14.6 MeV by using a Ge(Li) γ-ray detector. The following cross sections (in millibarns) have been obtained : ^{150}Sm(n,p) ^{150}Pm, 7.19$\pm$1.01 ; ^{173}Yb(n,p) ^{173}Tm, 13.5$\pm$2.8 ; ^{175}Lu(n,p) ^{175}Yb, 18.5$\pm$2.2 ; ^{146}Nd(n,α) ^{143}Ce, 4.42$\pm$0.47 ; ^{152}Sm(n,α) ^{149}Nd, 2.81$\pm$0.42 ; ^{174}Yb(n,α) ^{171}Er, 1.22$\pm$0.23 ; and ^{176}Lu(n,α) ^{173}Tm, 2.30$\pm$0.57. The results are compared with predictions of the evaporation model, the pre-equilibrium model and others. The present experimental (n,p) cross sections agree fairly well with the predictions of the pre-equilibrium model.
A comparison between the exprimental (n,α) cross sections and the predictions of the pre-equilibrium model seems to suggest the existence of the mechanism of the pre-equilibrium emission in the (n,α) reaction in this mass region.

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IV-7 (n,2n) Cross Sections on Nd, Sm, Gd and Yb at 14.6 MeV

I. Kumabe, E. Koutake and F. Nagahama*

Activation cross sections for the (n,2n) reactions on Nd, Sm, Gd and Yb have been measured at 14.6 MeV by using a 31 cm^3 Ge (Li) γ-ray detector. For some of these target nuclei threshold energies of the (n,3n) reactions are so low that the considerable (n,3n) cross sections are expected. The experimental results are shown in table 1.

The (n,2n) cross section can be calculated from the statistical compound-nucleus theory. Two typical calculations have been carried out by Pearlstein[1] and Gilbert and Gomberg[2]. Pearlstein calculated under the assumption that the compound nucleus emits a third neutron whenever, after the emission of the second neutron, it has sufficient energy to do so. On the other hand, Gilbert and Gomberg ignored completely the evaporation of a third neutron. In the present calculation, competition from the (n,2n) reaction is assumed at the energies above the (n,3n) threshold.

It is well known[3] that the pre-equilibrium process is dominant in the (n,p) and (n,n'γ) reactions at 14 MeV in this mass region. Therefore in the present calculation we took the contribution of the pre-equilibrium process into account.

The (n,2n) cross section is given by

$$\sigma_{(n,2n)} = \sigma_{ne} - \sigma_{(n,n'\gamma)} - \sigma_{(n,3n)} - \sigma_{(n,p)} - \sigma_{other}$$

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where σ_{ne} is the reaction cross section ; $\sigma_{(n,n'\gamma)}$ is the inelastic scattering cross section and it was calculated on the basis of both the pre-equilibrium process and the compound process ; $\sigma_{(n,3n)}$ is the (n,3n) cross section and its calculation was carried out by assuming the competition from (n,2n) reaction ; $\sigma_{(n,p)}$ is the (n,p) cross section and it was calculated on the basis of the pre-equilibrium process ; σ_{other} is the other cross sections which include the (n,α), (n,γ), (n,d), (n,np) and (n,nα) cross sections. The preliminary results are shown in table 1.
As is seen in this table, the present experimental (n,2n) cross sections agree fairly well with the present calculation except for ^{176}Yb.

Table 1. (n,2n) cross sections (mb)

	^{142}Nd	^{148}Nd	^{150}Nd	^{154}Sm	^{160}Gd	^{176}Yb
Experimental cross sections	1675 ± 160	1789 ± 147	1720 ± 128	2010 ± 137	2173 ± 152	2226 ± 152
Calculated cross sections	1822	1870	1758	2064	2089	2055

References :

1) S. Pearlstein, Nucl. Data A3 (1967) 327

2) A. Gilbert and R. Gomberg, UCRL 50736 (1969) unpublished

3) For example, G. M. Braga-Marcazza et al., Phys. Rev. C6, (1972) 1389, D. Hermsdorf et al., Kernenergie 16 (1973) 252

IV-8 Nuclear fission and structure studies by measuring the gamma-rays accompanied by ^{252}Cf spontaneous fission

Y. Yoshida, K. Tsuji and A. Katase

The paper on this subject was published in Genshikaku Kenkyu, Vol. 20, No. 1, 1975, (in Japanese) with an abstract with follows :

The idea and a part of the results of the gamma-gamma coincidence measurements of the gamma-rays accompanied by ^{252}Cf spontaneous fission now being performed by the present authors are reported for the case of Mo and Ba isotopes. The results about nuclear fission and structure which are expected to be found after the detail analysies of the present experimental data are also mentioned.

V. NAGOYA UNIVERSITY

Department of Nuclear Engineering, Faculty of Engineering

V-1 Fast Neutron Automatic Activation System

Susumu AMEMIYA, Morio ITOH, Kiyoshi KAWADE,
Hiroshi YAMAMOTO, and Toshio KATOH

A paper on this subject was published in J. Nucl. Sci. Technol., 11 (1974) 395.

A fast neutron irradiation system was designed for performing activation analyses with fast neutron on elements producing short-lived nuclides. The system consists of a Van de Graaff accelerator, a pneumatic transfer system, a γ-ray detection system and a control system. All the process steps of the activation analysis, such as irradiation, transfer of the sample and measurement of γ-rays are carried out in automatic sequence, governed by a programmed control system. The main part of this paper is devoted to a description of this control system. The apparatus was successfully tried for the analysis of ^{207m}Pb ($T_{1/2}$= 0.797 sec) produced through the reaction $^{208}Pb(n, 2n)^{207m}Pb$. The activity was identified with the apparatus set to measure half-life. Background can be reduced by selecting the time sequence of analyzing processes.

VI. NIPPON ATOMIC INDUSTRY GROUP CO., LTD.

Nuclear Research Laboratory

VI-1 Production of Decay Data using Gross Theory of Beta Decay [1)]

T. Yoshida

Lack of the experimental data on the β-decay half-life and energies of released β- and γ-ray gives rise to a large uncertainty in the after-heat calculations, which are of critical importance for the safety analyses of nuclear reactors. However, the complexity of orthodox nuclear theory prevents the calculation of requisite data.

On the other hand, the gross theory of β-decay developed by Takahashi and Yamada[2)] relieves these difficulties to some extent. FORTRAN codes for the half-life prediction originally developed by Takahashi[3)] were revised so as to yield the energy of released β- and γ-ray besides $\tau_{1/2}$. The codes deal with β^+-, β^--decay and electron capture.

An evaluation of the applicability of the gross theory to after-heat calculation was also performed. This assessment was based on the survey calculations for nearly 100 short-lived nuclides in FP region. Fig.1 shows a part of the outcomes of this survey [note)]. This figure indicates that the reliability

note) The theory includes a parameter Q_{00} which indicates the lowest level can be reached. The determination of Q_{00} has a critical importance for applying the theory to data production.

of the calculation tends to increase as the Q-value of the decay increases. This is an advantage of the present method because the experimental data are poorer for shorter-life nuclides. Further evaluation work is now under way.

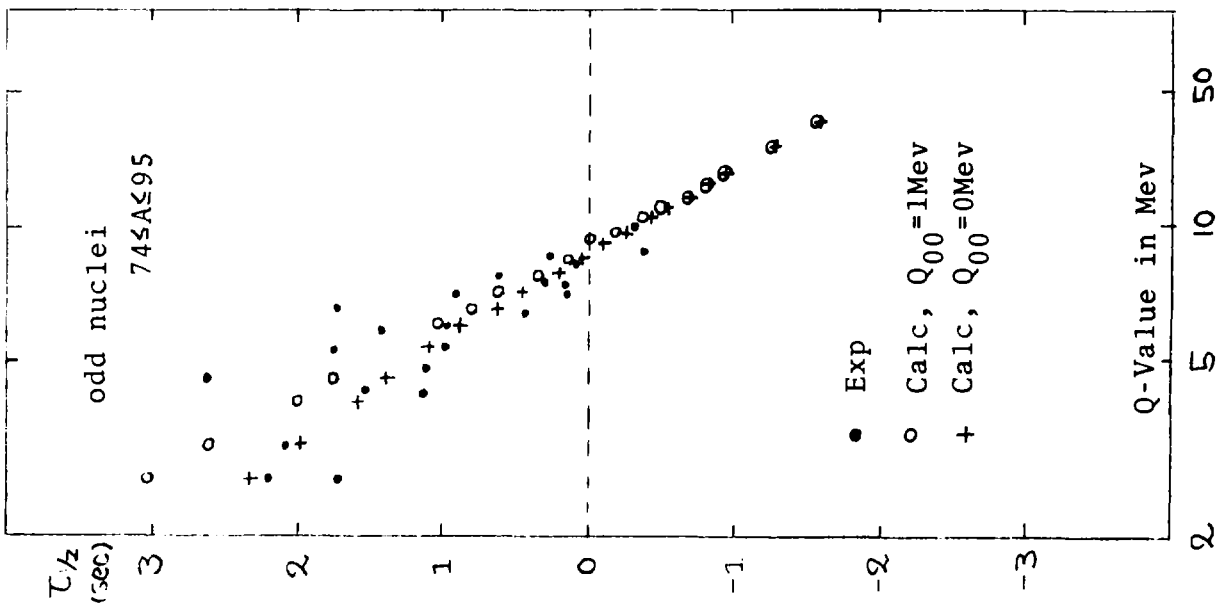

Fig.1 Half-Life of Short-Lived Fission Products

References;

1) T. Yoshida; JAERI-M Report, to be published (in Japanese)

2) for example, K. Takahashi, M. Yamada, T. Kondoh; Atom. and Nucl. Data Tables, 12, 101(1973)

3) T. Kondoh, M. Yamada; private communication

VII. Radiation Center of Osaka Prefecture

VII-1 Delayed Neutron Spectrum from the Photofission of Uranium

Kyue Fukuda

The energy distribution of neutrons from the short-lived neutron emitters produced in the photofission of natural uranium has been studied with a ^{3}He counter.

A thick target bremsstrahlung supplied from a 15 MeV linear electron accelerator was used to produce photofission in a natural uranium target of 6 cm diameter by 0.5 cm thick. Delayed neutrons emitted from the target were measured between beam pulses with a ^{3}He proportional counter placed at 30 cm from the target. The amplifier for the pulses from the counter was gated off during the electron beam and for 3 msec thereafter.

The preliminary experiments showed a continous energy distribution from 0.1 to 1.5 MeV. The spectrum is a composite of the individual delayed groups, because counting is made after equibrium is reached. The spectrum displayed eight shoulders at energies of 0.16, 0.25, 0.35, 0.46, 0.64, 0.68, ∿0.75 and ∿0.86 MeV. These shoulders well correspond to the peaks of the delayed neutron spectra from ^{87}Br and ^{137}I reported by Shalev et al.[1] except for the shoulders at 0.64 and 0.68 MeV.

1) S. Shalev and G. Rudstam, Nucl. Phys. A230(1974)153

VIII. THE INSTITUTE OF PHYSICAL AND CHEMICAL RESEARCH

VIII-1 Compilation of Data on Half-Lives of Actinide Nuclei -- Total Half-Lives of ^{238}Pu, ^{241}Pu, ^{242}Pu, ^{234}U, ^{235}U, ^{236}U and Spontaneous Fission Half-Lives of ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu --

A. Hashizume* and H. Kawakami†

The 48 data on total half-lives of ^{238}Pu, ^{241}Pu, ^{242}Pu, ^{234}U, ^{235}U, ^{236}U and the 16 data on spontaneous fission half-lives of ^{238}Pu, ^{239}Pu, ^{240}Pu and ^{242}Pu have been compiled. Recommended values which are the weighted mean of evaluated data are as follows.

Total half-lives

^{238}Pu: 87.55 ± 0.11 y

^{241}Pu: 14.72 ± 0.15 y

^{242}Pu: $(3.840 \pm 0.034) \times 10^5$ y

^{234}U : $(2.476 \pm 0.014) \times 10^5$ y

^{235}U : $(7.038 \pm 0.069) \times 10^8$ y

^{236}U : $(2.3419 \pm 0.0037) \times 10^7$ y

Spontaneous fission half-lives

^{238}Pu: $(5.1 \pm 0.4) \times 10^{10}$ y

^{239}Pu: 5.5×10^{15} y

^{240}Pu: $(1.351 \pm 0.025) \times 10^{11}$ y

^{242}Pu: $(6.88 \pm 0.17) \times 10^{10}$ y

* The Institute of Physical and Chemical Research

† Institute for Nuclear Study

IX. Tokyo Institute of Technology

A. Faculty of Science

IX-A-1 Penetration Effects for Internal Conversions in the Odd-Mass Isotopes of La and Cs

Atsuo Morinaga and Kazuo Hisatake

A paper on this subject was published in J. Phys. Soc. Japan 38 (1975) 322 with an abstract as follows:

Penetration parameters λ are determined by using internal conversion intensities and coefficients for low energy hindered M1 transitions of ^{131}Cs, ^{135}La, ^{137}La and ^{139}La together with E2/M1 mixing ratios δ^2. The results are; λ(86.9, ^{135}La)=14.5±5.5, λ(10.5, ^{137}La)=10±5, λ(166, ^{139}La)=3.6±1.8 and λ(92.3, ^{131}Cs)=4±4, where numbers in parentheses are transition energies in keV.

IX-A-2 Internal conversion Electrons and γ-Rays from the Decay of ^{206}Po

Masaaki Kanbe, Manabu Fujioka and Kazuo Hisatake

A paper on this subject was published in J. Phys. Soc. Japan 38 (1975) 917 with an abstract as follows:

Internal conversion electrons and γ-rays following the decay of ^{206}Po were measured with a $\pi\sqrt{2}$ iron-free β spectrometer and Ge(Li) detectors. The energies and intensities of 80 transitions including 60 new ones have been determined. Especially, we identified a new intense M1 transition of 10.84 keV. The multipolarities for 64 transitions were determined from K-conversion coefficients and L- and M-subshell ratios. γ-γ coincidences employing two Ge(Li) detectors were also performed.

IX-A-3 Level Structure of ^{206}Bi Studied from the Decay of ^{206}Po

Masaaki Kanbe, Manabu Fujioka and Kazuo Hisatake

A paper on this subject was published in J. Phys. Soc. Japan 38 (1975) 928 with an abstract as follows:

Using the results of our conversion-electron and γ-ray measurements in the decay of ^{206}Po, a decay scheme of ^{206}Po is proposed as follows: 0[6^+], 59.91[4^+], 70.76[3^+], 82.83[5^+], 200.40[4^+], 352.71[$(4,3)^+$], 409.19[2^+], 523.23[3^+], 733.93[3^+], 878.12[2^+], 897.10[3^+], 931.70[1^+], 1077.89[2^+], 1103.02 [2^+], 1264.77[$(2,3,4)^+$], 1389.45[1^+], 1523.67[1^+], 1567.57[$1^+(2^+)$] and 1600.14 keV [$0^+(1^+)$]. In the present decay scheme the previous discrepancy between spin-parities and log ft values has been removed. The low-lying states in ^{206}Bi are interpreted in terms of one-proton, three-neutron-hole configurations outside the doubly closed ^{208}Pb core.

B. Research Laboratory for Nuclear Reactors

IX-B-1 Measurement of Neutron Capture Cross Section near 24 kev

N. Yamamuro, T. Doi, T. Hayase, Y. Fujita*, K. Kobayashi,* and R.C. Block**

Neutron capture cross section of ^{93}Nb, Ag, ^{127}I, ^{165}Ho, ^{197}Au, and ^{238}U were measured near 24 kev using the Fe-filtered-beam method. A 15 cm thick Fe filter was placed in the neutron time-of-flight beam produced by the KUR 46 Mev electron Linac. Capture gamma-rays were detected by two C_6F_6 total energy detectors located on a 12 m flight path. Pulse-height weighting was used to determine the relative capture efficiency. The neutron flux was determined with the detector via the $^{10}B(n,\alpha_1\gamma)$ reaction and saturated resonance capture in Ag at 5.2 ev. Multiple scattering correction was applied to the data, resulting in 24 kev capture cross sections shown in Table. Total errors are 5 to 7%, with an estimated systematic error of 4%.

Table: 24 kev Neutron Capture Cross Sections

Element	N (10^{-3}a/b)	f # (%)	Statistical Error (%)	σ_γ (b)
^{93}Nb	5.26	7.8	3.0	0.33
Ag	2.98	4.3	2.4	1.10
^{127}I ##	4.96	7.1	2.7	0.76
^{165}Ho	6.63	11.6	2.5	1.26
^{197}Au	2.89	6.0	3.3	0.68
^{238}U ###	1.30	4.1	6.0	0.50

f means the sample scattering correction.
PbI_2 in a Al capsule is used.
Contents of ^{235}U is <400 ppm.

*Kyoto University Research Reactor Institute

**Visiting Professor at Kyoto University from Rensselaer Polytechnic Institute

IX-B-2 Direct and Collective Radiative Captures of Energetic Neutrons by Deformed Nuclei

H. Kitazawa, T. Hayase, A. Mori*, and N. Yamamuro

Recently some authors have shown by systematic analyses of (n,γ) and (p,γ) reactions that nucleon radiative capture phenomena in the giant dipole resonance energy region are successfully interpreted by the direct and collective capture models, using the volume coupling Hamiltonian and the reasonable isospin potential depth. We have applied these models to the radiative capture of energetic neutrons by deformed nuclei. In this case it is assumed that the nuclear state retains its axial symmetry during the reaction process. The initial, intermediate, and final state wave functions are described with the adiabatic approximation. Contributions to the capture cross section from different rotational bands corresponding to the intrinsic states of a residual nucleus are calculated by the coupled channel method. Fig. (1) shows the excitation curves for the direct (σ_D), collective (σ_C), interference (σ_I), and total processes in the $^{238}U(n,\gamma)^{239}U$ reaction. The strength of the particle-vibration coupling v_1 is taken to be 110 MeV and the deformation parameter β to be 0.268. The initial state wave function is obtained with the optical potential parameters, taken from the work of Rosen et al.[1] The dotted curve is calculated including the Nilsson orbits [862], [871], and [880]. The experimental point of a closed circle is taken from the work of Drake et al.[2] Fig. (2) shows the excitation curve for the 5/2+[622] band. The neutron single particle levels in ^{239}U involved in this calculation are given

by Fig. (3). Level schemes (a), (b), and (c) are the theoretical result by Boisson and Jang[3], our result calculated with the modified JUPITOR code[4], and the experimentally observed[5], respectively. The giant dipole resonance energy and its width in ^{238}U are taken from the experiment of photo-nuclear reaction.[6]

References:

1) L. Rosen et al., Ann. of Phys. 34 (1965) 69

2) D. Drake et al., Phys. Lett. 36B (1971) 557

3) J. P. Boisson and S. Jang, Nuclear Phys. A189 (1972) 334

4) A. Mori, private communication

5) R. K. Sheline et al., Phys. Rev. 15 (1966) 1011

6) A. Veyssiere et al., Nuclear Phys. A199 (1973) 45

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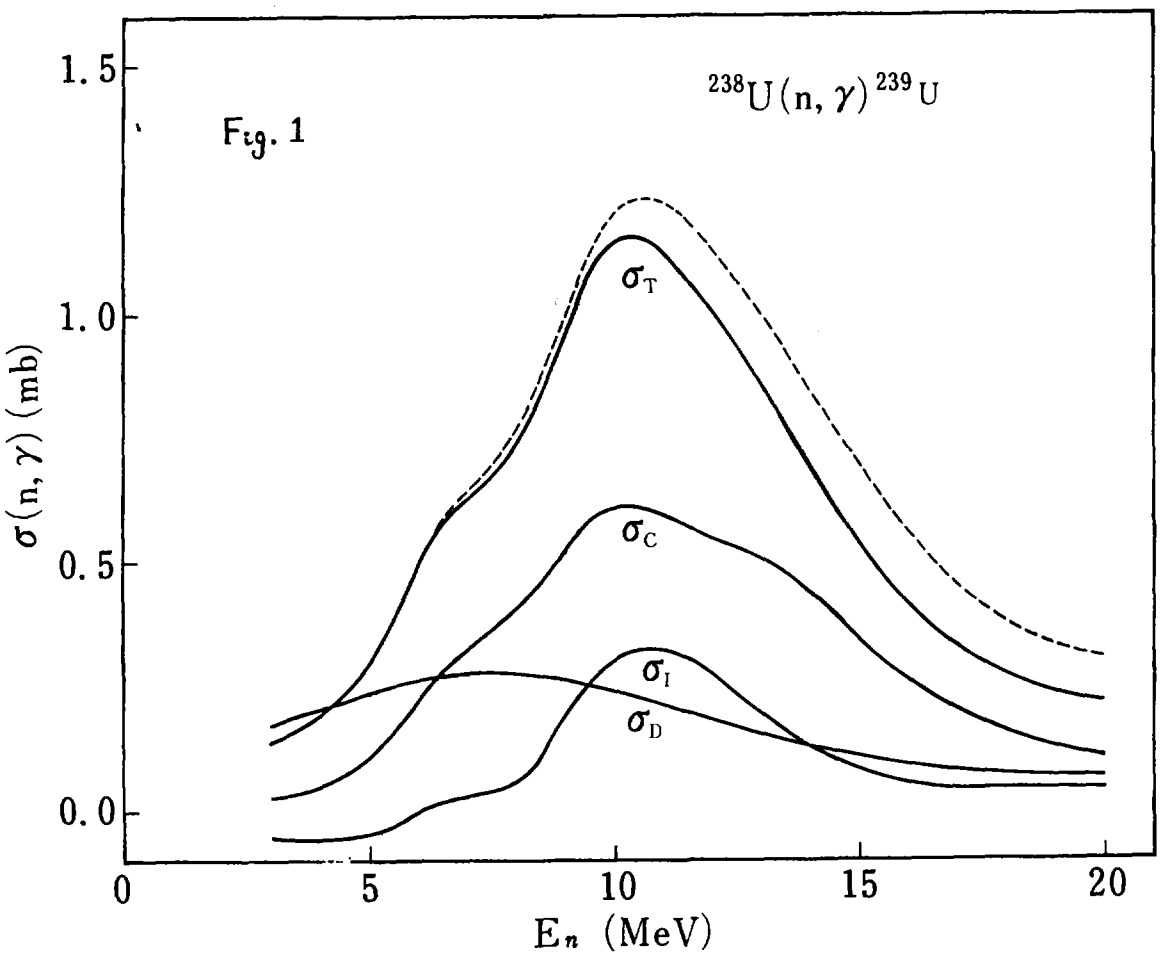
Fig. 1
$^{238}U(n,\gamma)^{239}U$
σ_T
σ_C
σ_I
σ_D
$\sigma(n,\gamma)$ (mb)
1.5
1.0
0.5
0.0
0
5
10
15
20
E_n (MeV)

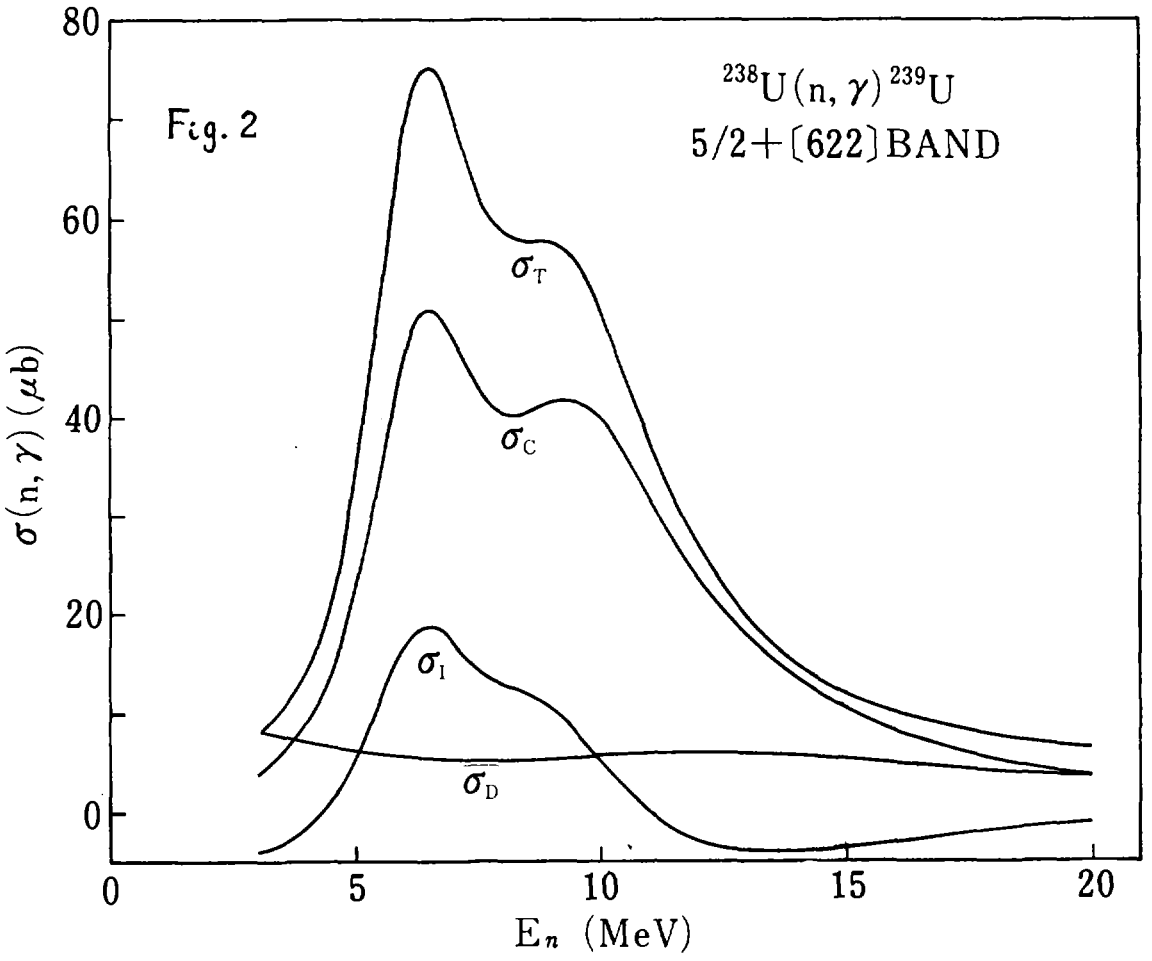
Fig. 2
$^{238}U(n,\gamma)^{239}U$
5/2+[622]BAND
σ_T
σ_C
σ_I
σ_D
$\sigma(n,\gamma)$ (μb)
80
60
40
20
0
0
5
10
15
20
E_n (MeV)

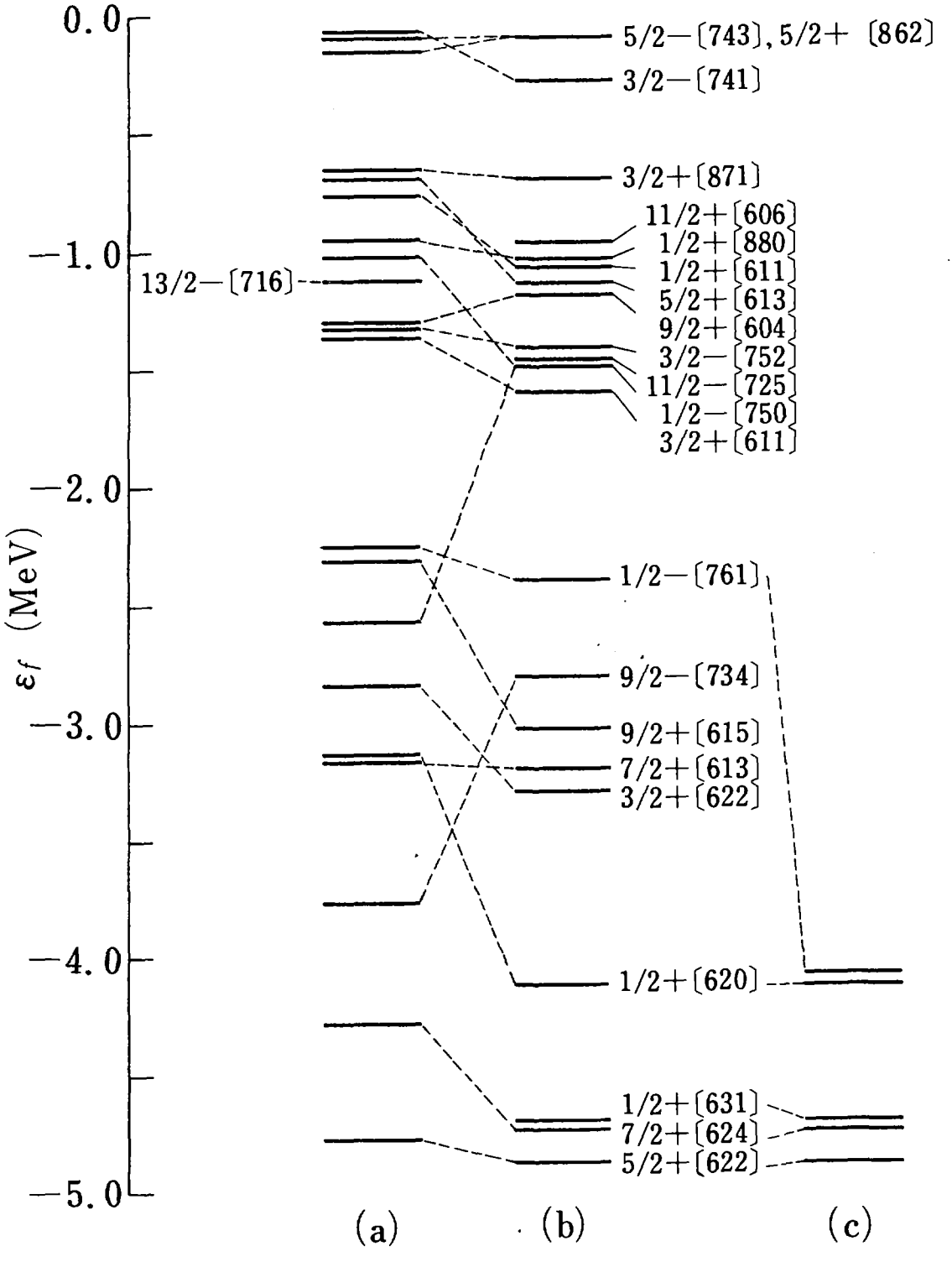
0.0
−1.0
−2.0
−3.0
−4.0
−5.0
ε_f (MeV)
13/2−〔716〕
5/2−〔743〕, 5/2+ 〔862〕
3/2−〔741〕
3/2+〔871〕
11/2+〔606〕
1/2+〔880〕
1/2+〔611〕
5/2+〔613〕
9/2+〔604〕
3/2−〔752〕
11/2−〔725〕
1/2−〔750〕
3/2+〔611〕
1/2−〔761〕
9/2−〔734〕
9/2+〔615〕
7/2+〔613〕
3/2+〔622〕
1/2+〔620〕
1/2+〔631〕
7/2+〔624〕
5/2+〔622〕
(a)
(b)
(c)

Fig. 3